C 1
3:79
c.2

North Carolina State Library
Raleigh

N. C.
Doc.

NORTH CAROLINA

DEPARTMENT OF CONSERVATION AND DEVELOPMENT

DAN E. STEWART, *Director*

DIVISION OF MINERAL RESOURCES

STEPHEN G. CONRAD, *State Geologist*

Bulletin Number 79

Description of the Pungo River Formation

in Beaufort County, North Carolina

By

Joel O. Kimrey
Hydraulic Engineer, U. S. Geological Survey

Prepared Cooperatively by the Geological Survey
United States Department of the Interior

1965

NORTH CAROLINA

DEPARTMENT OF CONSERVATION AND DEVELOPMENT

DAN E. STEWART, *Director*

DIVISION OF MINERAL RESOURCES

STEPHEN G. CONRAD, *State Geologist*

Bulletin Number 79

Description of the Pungo River Formation

in Beaufort County, North Carolina

By

Joel O. Kimrey
Hydraulic Engineer, U. S. Geological Survey

Prepared Cooperatively by the Geological Survey

United States Department of the Interior

1965

MEMBERS OF THE BOARD OF CONSERVATION AND DEVELOPMENT

James W. (Willie) York, Chairman	Raleigh
R. Patrick Spangler, First Vice Chairman	Shelby
William P. Saunders, Second Vice Chairman	Southern Pines
John M. Akers	Gastonia
John K. Barrow, Jr.	Ahoskie
J. O. Bishop	Rocky Mount
David Blanton	Marion
Robert E. Bryan	Goldsboro
William B. Carter	Washington
Arthur G. Corpening, Jr.	High Point
Moncie L. Daniels, Jr.	Manteo
Koy E. Dawkins	Monroe
Dr. J. A. Gill	Elizabeth City
John Harden	Greensboro
Gilliam K. Horton	Wilmington
Dr. Henry W. Jordan	Cedar Falls
Petro Kulynych	Wilkesboro
William H. Maynard	Lenoir
W. H. (Shorty) McDonald	Tryon
Jack Pait	Lumberton
John A. Parris, Jr.	Sylva
Oscar J. Sikes, Jr.	Albemarle
T. Max Watson	Spindale
L. W. Wilson	Robbinsville

Letter of Transmittal

Raleigh, North Carolina
September 23, 1965

To His Excellency, HONORABLE DAN K. MOORE
Governor of North Carolina

Sir:

I have the honor to submit herewith manuscript for publication as Bulletin 79, "Description of the Pungo River Formation in Beaufort County, North Carolina," by Joel O. Kimrey, Hydraulic Engineer, U.S. Geological Survey.

This report was prepared by the U.S. Geological Survey in cooperation with the North Carolina Department of Conservation and Development and the Beaufort County Board of Commissioners. It contains the results of a detailed geologic investigation of the phosphorite unit in Beaufort County, and should prove to be of considerable value to the landowners and those interested in the economic development of this important mineral resource.

Respectfully submitted,

DAN E. STEWART
Director

Digitized by the Internet Archive
in 2013

http://archive.org/details/descriptionofpun1965kimr

TABLE OF CONTENTS

Page

Abstract . . . 1

Introduction . . . 1

- Scope and purpose . . . 1
- Cooperation and direction . . . 1
- Previous work . . . 1
- Acknowledgments . . . 2

Geography . . . 2

- Area and population . . . 2
- Physiography . . . 2
- Climate . . . 2
- Economy . . . 2
- Transportation . . . 3

Methods of investigation . . . 3

- Gamma-ray logs and interpretation . . . 3
- Range of EI for materials in the Pungo River Formation . . . 4
- Resistivity logs and interpretation . . . 4

Geology . . . 4

- Introduction . . . 4
- Post-Miocene sands and gravels . . . 5
- Yorktown Formation . . . 5
- Pungo River Formation . . . 5
- Castle Hayne Limestone . . . 6

Ground-water hydrology . . . 6

- Introduction . . . 6
- Hydrologic properties of the geologic formations . . . 6
  - Post-Miocene sands and gravels . . . 6
  - Yorktown Formation . . . 6
  - Pungo River Formation . . . 7
  - Castle Hayne Limestone . . . 7
- Relation of water to possible mining operations . . . 7

Geology of the Pungo River Formation . . . 7

- Structural geology . . . 7
- Lithology . . . 8

Systematic description of the Pungo River Formation . . . 8

- Introduction . . . 8
- Criteria used on fence diagram . . . 9
  - High grade phosphatic sand . . . 9
  - Phosphatic sand . . . 9
  - Clay . . . 9
  - Indurations . . . 9
- Belhaven quadrangle . . . 9
- Pamlico Beach quadrangle . . . 10
- Lowland quadrangle . . . 10
- Pike Road quadrangle . . . 10
- Pantego quadrangle . . . 11
- Ransomville quadrangle . . . 11
- South Creek quadrangle . . . 12
- Pinetown quadrangle . . . 12

TABLE OF CONTENTS

Page

- Bath quadrangle 12
- Aurora quadrangle 13
- Bunyan quadrangle 14
- Blounts Bay quadrangle 14
- Edward quadrangle 14

Economic geology 14

Suggestions for future prospecting 15

Basic data 15

- Introduction 15
- Lithologic logs 15
  - Aurora quadrangle 17
    - AU (South)-1-GRL 17
  - Belhaven quadrangle 19
    - BE-2-GRL 19
    - BE-3-GRL 23
    - BE-6-L 24
    - BE-8-GRL 26
    - BE-12-GL 28
  - Bunyan quadrangle 30
    - BU-10-GRL 30
  - Pantego quadrangle 31
    - PA-22-GRL 31
    - PA-24-GRL 33
    - PA-31-GRL 34
  - Pamlico Beach quadrangle 38
    - PB-2-GRL 38
    - PB-4-GL 41
  - Pinetown quadrangle 45
    - PI-1-GRL 45
    - PI-5-GRL 46
    - PI-16-GRL 48
    - PI-23-GRL 50
  - Pungo Lake quadrangle 52
    - PL-1-GRL 52
  - Pike Road quadrangle 53
    - PR-1-GRL 53
    - PR-2-GRL 54
    - PR-3-GRL 56
  - Ransomville quadrangle 57
    - RA-13-GRL 57
    - RA-34-GRL 60
  - South Creek quadrangle 62
    - SC-10-GRL 62
    - SC-17-GRL 65
- Beneficiation data 69
- Gamma-ray and resistivity logs 69

Selected references 69

ILLUSTRATIONS

Page

Table 1. Beneficiation data for selected core samples from core holes: PA-31, RA-34, PB-4, PB-2,
BE-8, BE-6, PI-5, SC-10, and SC-17 70
PI-16, PI-23, PA-22, PA-24, RA-13, and BE-2 72

Plate 1. Geophysical logs in Belhaven quadrangle 75
2. Geophysical logs in Pamlico Beach quadrangle 78
3. Geophysical logs in Pantego quadrangle 79
4. Geophysical logs in Ransomville quadrangle 86
5. Geophysical logs in South Creek quadrangle 93
6. Geophysical logs in Pinetown quadrangle 98
7. Geophysical logs in Bath quadrangle 105
8. Geophysical logs in Aurora quadrangle 110
9. Geophysical logs in Bunyan quadrangle 124
10. Geophysical logs in Blounts Bay quadrangle 127
11. Geophysical logs in Edward quadrangle 129

Facing Page

Figure 1. Map of eastern portion of North Carolina showing location of Beaufort County and adjacent counties 2
2. Comparison of laboratory and field data for gamma-ray activity versus P_2O_5 content of phosphorites 3
3. Comparison of gamma-ray and resistivity logs, lithology, and P_2O_5 content of material from a core hole 4
4. Map of Beaufort County showing location of topographic quadrangles used for base map 5
5. Base map showing location of core holes and of wells for which geophysical logs were made . . . . . In Pocket
6. Isometric fence diagram of the Pungo River Formation in Beaufort County, North Carolina . . . . . In Pocket
7. Contours on top of the Pungo River Formation in Beaufort County, North Carolina . . . . . In Pocket
8. Contours on top of the Castle Hayne Limestone in Beaufort County, North Carolina . . . . . In Pocket

Description of the Pungo River Formation in Beaufort County, North Carolina

JOEL O. KIMREY

ABSTRACT

This report describes the lithology and stratigraphy of the Pungo River Formation that underlies part of Beaufort County, North Carolina. The formation contains potentially economic beds of phosphatic sand. It is composed of interbedded phosphatic clays, diatomaceous clays, phosphatic limestones, silty claystones, coquinas, calcareous clays, and phosphatic sands. The $P_2 O_5$ content of the phosphatic sands ranges up to a known maximum of about 21 percent of the raw core sample. The above materials usually occur in definite zones, or horizons, in the formation that may be traced laterally across the county.

The depth and thickness of the Pungo River Formation and the delineation of lithologic zones within the formation were determined by gamma-ray logs of existing water wells and gamma-ray and resistivity logs of core holes that penetrated the unit. Additional core holes were then drilled and the $P_2 O_5$ content of material from the core holes was determined. It was determined that there is a generally direct relationship between the gamma-ray emmission intensity of the phosphatic sands in the formation and their $P_2 O_5$ content. This relationship was used to estimate $P_2 O_5$ contents where core-hole and analytical data was not available.

Beaufort County is in the east-central part of the North Carolina Coastal Plain. Its economy is geared primarily to production of agricultural and timber products.

The Pungo River Formation was apparently deposited in a northeast-southwest trending basin whose axis lies southeast of Beaufort County. Subsequent downwarping to the southeast has resulted in erosional beveling of the top of the formation. The formation underlies more than 700 square miles of the eastern part of Beaufort County. Its thickness ranges from a featheredge, a few miles east of the city of Washington, to more than 120 feet near the south shore of the Pamlico River in eastern Beaufort County. Its depth below mean sea level ranges from a minimum of about 40 feet near its western limits to more than 230 feet in the northeastern part of the county.

A fence diagram of the formation, lithologic logs, $P_2 O_5$ analyses, beneficiation data, and selected gamma-ray and resistivity logs are included in this report.

INTRODUCTION

Scope and Purpose

The Ground Water Branch of the U. S. Geological Survey began a geologic and ground-water investigation in Beaufort County, North Carolina in March, 1962. The purpose of the investigation was to evaluate the ground-water resources of the part of the county underlain by the Pungo River Formation and to delineate the potentially economic phosphorite horizons in the formation. This report is concerned primarily with descriptions of the phosphorite horizons in the formation.

Cooperation and Direction

The investigation was made by the U. S. Geological Survey in financial cooperation with the North Carolina Division of Mineral Resources and the Beaufort County Board of Commissioners. The field work and preparation of this report was done under the immediate supervision of P. M. Brown, District Geologist, and under the general supervision of O. M. Hackett, Chief, Ground Water Branch, U. S. Geological Survey.

Previous Work

Brown (1958) described a phosphorite unit in Beaufort County from data that resulted from a five-county ground-water reconnaissance project that included Beaufort County. Kimrey (1964) proposed the designation, Pungo River Formation, for this phosphorite unit. The writer has previously described the geophysical log interpretive techniques used during this investigation (Kimrey, 1962).

Acknowledgments

Several U. S. Geological Survey personnel participated in the collection of field data for this project. They included Gerald E. Idler, G. W. Lutz, and Earl I. Stebbins. P. M. Brown identified the microfossils used for stratigraphic correlations in this report. James A. Miller described the lithology of the core samples obtained during this investigation.

Dr. J. L. Stuckey, State Geologist, N. C. Division of Mineral Resources, offered valuable suggestions and criticisms concerning the field work. Stephen G. Conrad, Assistant State Geologist, N. C. Division of Mineral Resources, assisted with various phases of the field work.

The County Commissioners, other public officials, and interested private citizens, of Beaufort County gave their time to furnish information helpful in conducting field work. Mr. M. P. Chesnutt, County Agricultural Agent for Beaufort County, was particularly helpful in this respect. The writer also wishes to extend thanks to the numerous owners of domestic water wells that allowed gamma-rays logs to be made of their wells.

Also due acknowledgment are representatives of several companies who afforded useful data of various types. The companies include American Cyanamid Company, Huber Clay Company, Humble Oil and Refining Company, Magnet Cove Barium Company, North Carolina Phosphate Corporation, and Texas Gulf Sulfur Company.

GEOGRAPHY

Area and Population

Beaufort County is in the east-central portion of the North Carolina Coastal Plain (fig. 1). It contains 831 square miles according to the 1963 North Carolina Almanac; however, this figure does not include the submerged land in the county.

The county has a population of 36,014 according to the 1960 census. Urban population, centered in Washington and Washington Park (combined population 10,513) and Belhaven (population 2,386) accounts for 36 percent of the total population. The remaining 64 percent of the population is considered rural and is centered around small towns and villages which include Aurora, Bayview, Bath, Chocowinity, Edward, Pantego, Pinetown, and Terra Ceia.

Physiography

Beaufort County lies entirely within the Atlantic Coastal Plain province. Land surface elevations range from sea level at Pamlico Sound in the eastern part of the county to more than 60 feet above sea level in the western part of the county. The most prominent topographic feature in the county is a relict beach ridge which trends across the county in a northerly direction. It is most prominent just east of the village of Edward on the south side of the Pamlico River. Generally, land surface elevations in excess of 30 feet above sea level prevail west of the beach ridge, whereas land surface elevations less than 30 feet prevail east of the beach ridge. Relief is most prominent near streams except for localized dune sand deposits. The county is drained into Pamlico Sound by the Pamlico and Pungo Rivers and their tributary creeks. Drainage is poor; swamps occupy large areas of the county. Tillable land in the county east of the beach ridge usually requires drainage.

Climate

Records of the U. S. Weather Bureau Station at Washington indicate an average annual precipitation of about 51.6 inches. Rainfall is heaviest during the summer months but is relatively evenly distributed throughout the year. Temperature records from the Washington station indicate an average annual mean temperature of 61.7 degrees fahrenheit.

Economy

The economy of the county is primarily agricultural. The few industries are relatively small and include textile plants and food processing facilities. Commercial fishing supplies some income. A considerable portion of the total county area is forested, and lumbering operations for pulpwood and sawtimber are common. The gross annual income from lumbering now averages about $6,000,000.

The agricultural products that provide the major source of income for the county include tobacco, soy beans, corn, poultry and livestock. The total annual income from these products currently averages in excess of $12,000,000.

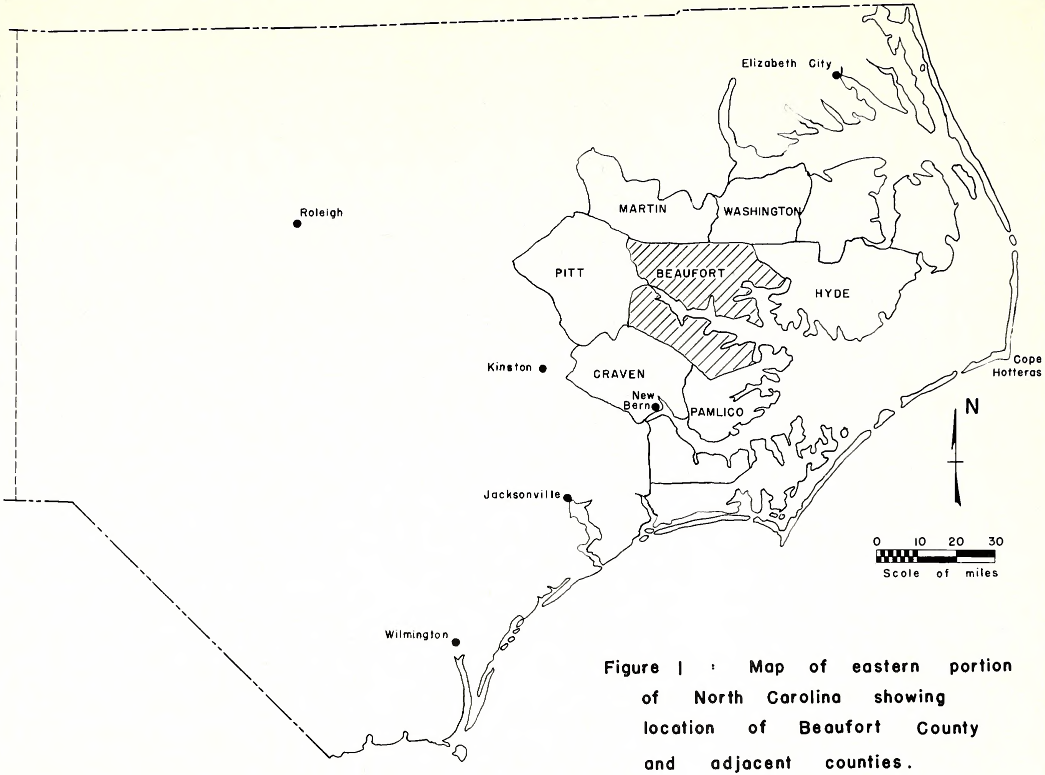
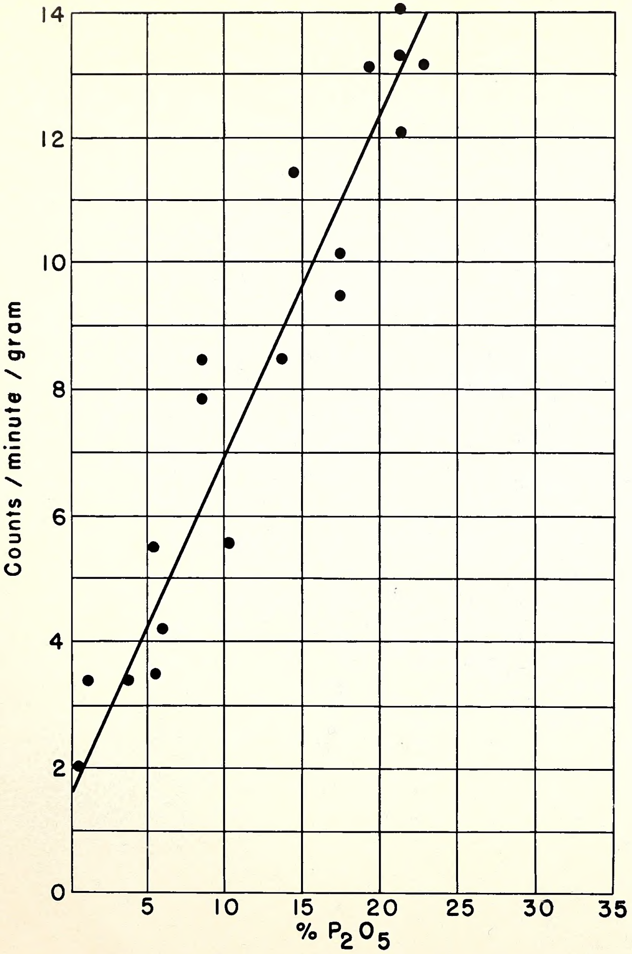
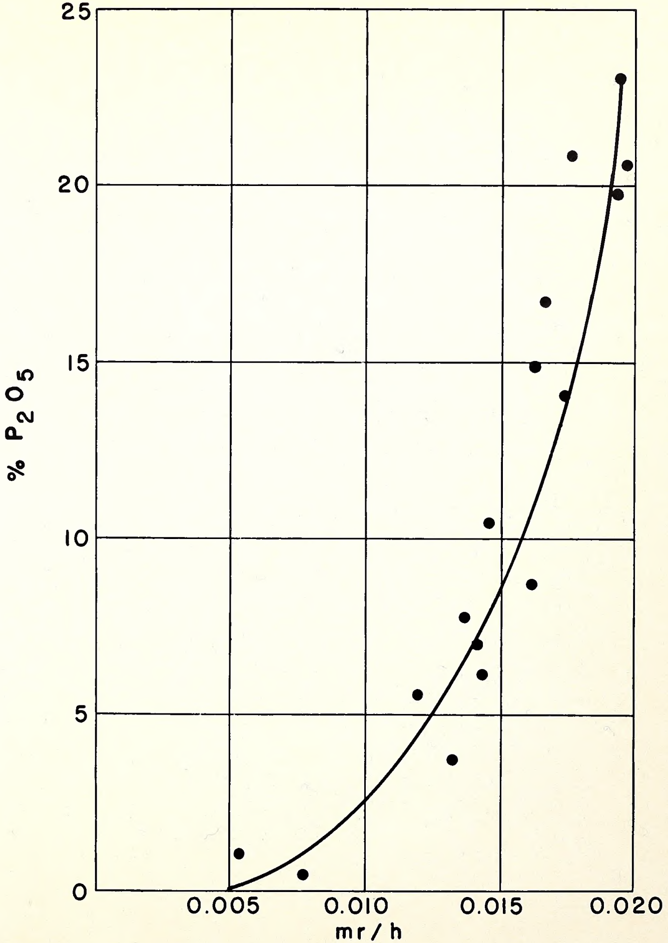


Figure 1 : Map of eastern portion of North Carolina showing location of Beaufort County and adjacent counties.

Figure 2



PLOT 1 – TOTAL GAMMA-RAY ACTIVITY VS P_2O_5 CONTENT



PLOT 2 – APPARENT DEFLECTION ON GAMMA-RAY LOGS VS P_2O_5 CONTENT

Transportation

The county is divided roughly into a northern two-thirds and a southern one-third by the Pamlico River which flows east-southeast across the county. The only highway crossing the river in the county is at Washington in the western part of the county. This precludes direct highway travel between the northeastern and southeastern parts of the county. With this exception, the county is served by an adequate network of state and federal roads.

The city of Washington is served by the Atlantic Coast Line and Norfolk Southern Railroads. Pinetown, Pantego, and Belhaven, on the north side of the Pamlico River are also served by the Norfolk Southern. There is no rail service on the south side of the Pamlico River except in the extreme western portion of the county where the Norfolk Southern Railroad parallels U. S. Highway 17.

The Pamlico and Pungo rivers afford commercial water transportation within their limits of channel depth and water-level fluctuation. The Intracoastal Waterway traverses eastern Beaufort County and allows access to both the Pamlico and Pungo rivers.

METHODS OF INVESTIGATION

As previously stated, this report is concerned primarily with the description of the Pungo River Formation that underlies part of Beaufort County. This description is based on delineation of the various horizons in the formation by interpretation of gamma-ray logs that were made of existing water wells and gamma-ray and resistivity logs that were made of core holes. The interpretations were substantiated by laboratory analyses of the phosphate content of material obtained from core holes. A discussion of gamma-ray and electric logs and their interpretation is included here since numerous references to this subject are included in the remainder of this report.

Gamma-ray Logs and Interpretation

Gamma-ray well logging equipment measures the gamma radiation emitted by the natural atomic decay of earth materials. Different rock types in an area usually have different ranges of emission intensity so that a gamma-ray log allows interpretation of the materials penetrated by a well. Gamma-ray emission intensity was measured in milliroentgens per hour $(\frac{mr}{h})$ by the logging equipment that was used for this investigation. In the remainder of this report, the term gamma-ray emission intensity, which means the apparent amount, or level, of gamma radiation indicated by gamma-ray logs for various materials will be abbreviated as EI.

Laboratory data indicates that the gamma radiation of the Beaufort County phosphorites is directly proportional to the $P_2 O_5$ content of the raw material, within the limits of empirical data. The first plot in figure 2 illustrates this relationship. The analytical data indicates that the principal source of gamma radiation in the material is uranium and thorium; radioactive potassium contributes a negligible amount of radiation.

The second plot in figure 2 is a plot of apparent gamma radiation, or EI, from gamma-ray logs, versus $P_2 O_5$ content of the material. This curve does not show the linear relationship between $P_2 O_5$ content and gamma radiation shown in plot 1. This disparity between laboratory and field data is apparently due to the difference in sensitivity between laboratory and field equipment.

The geologic materials that compose the Pungo River Formation in Beaufort County may be generally classified as follows: phosphatic sands, intercalated limestones and silty claystones, and clays.

The higher grade phosphatic sands in the formation have the highest EI of any material logged during this project. Lower grade phosphatic sands have a lower EI, and clays and limestones in the formation have a correspondingly lower EI. The rocks that overlie and underlie the Pungo River Formation also have low EI's so that gamma-ray logs permit qualitative differentiation of both the formation and zones within the formation.

Figure 3 shows a gamma-ray log and a resistivity log for a core hole located in the northeastern part of the county; the lithology and $P_2 O_5$ content of the material from the core hole are also shown. This figure illustrates the relationship between the EI and $P_2 O_5$ content of the phosphorites; generally, a higher EI indicates higher grade material. This core hole contained most of the lithologic horizons that occur in the Pungo River Formation throughout the area. The EI of the horizons in this core hole are typical of those horizons wherever they occur in the area.

Quantitative estimates of P_2O_5 content may be made from gamma-ray logs because of the following factors: (1) lithologic horizons in the formation are traceable for considerable distances, (2) P_2O_5 content in the major horizons does not vary radically in any lateral direction, and (3) this lithologic and grade homogeneity allows grouping of gamma-ray logs into log patterns or "curve families" that permit quantitative estimates of grade over considerable areas when the curve families are validated by analytical data from core holes. For this investigation, all major curve families were validated with at least one core hole.

All logs included in this report were made using a logging speed of 10 to 12 feet per minute (fpm) and with the recording unit set for ~~0.2~~ 0.02 milliroentgens per hour $(\frac{mr}{h})$ for full scale deflection on the logger chart paper and a time constant (tc) of 16 seconds. This logging speed, sensitivity, and time constant were determined to be optimum for obtaining the best definition of lithologic breaks and repetition of up and down logs in the same hole within a reasonable period of time.

Range of EI for Materials in the Pungo River Formation

The general range of EI values for the various materials in the Pungo River Formation are tabulated below:

Lithology	P_2O_5 content (percent)	EI range $(\frac{mr}{h})$
High grade phosphatic sand	Greater than 14	0.017-0.021
Phosphatic sand	10-14	0.015-0.017
Clays	Less than 10	0.006-0.015
Indurations, includes limestones and silty claystones	Less than 10	0.006-0.015

Factors that must be considered, particularly when making quantitative P_2O_5 estimates from gamma-ray logs, that alter the apparent EI of phosphatic material penetrated by a given well, include the following:

(1) The presence or absence, diameter, thickness and physical condition of well casing.

(2) The logging speed and time constant used may preclude or subdue the definition of thinner strata on the chart paper.

(3) The sensitivity of the logging equipment, although checked frequently, may vary between holes due to bumping of the logging equipment during transportation or for other reasons.

(4) Statistical variation, or random bursts of high or low EI, may lead to incorrect interpretation; however, this was partly compensated for by logging both up and down in each hole where practical.

Resistivity Logs and Interpretation

Resistivity logs measure the electrical resistivity of the materials penetrated by an open bore hole. This resistivity is governed by the physical characteristics of the rocks and the chemical characteristics of their contained fluids. The resistivity logs included in this report were all obtained from bore holes that penetrated sediments containing fresh water and with unconditioned drilling mud as the bore-hole fluid. To generalize, clean sands containing fresh water have relatively high resistivities, whereas, silty and clayey sands and clays that contain fresh water have progressively lower resistivities. The presence of brackish or salty water in sediments reduces their resistivity. Limestones that contain fresh water have a relatively high resistivity; dense limestones may be so resistive that the presence of brackish water in their interstitial spaces may be difficult to detect on the resistivity curve.

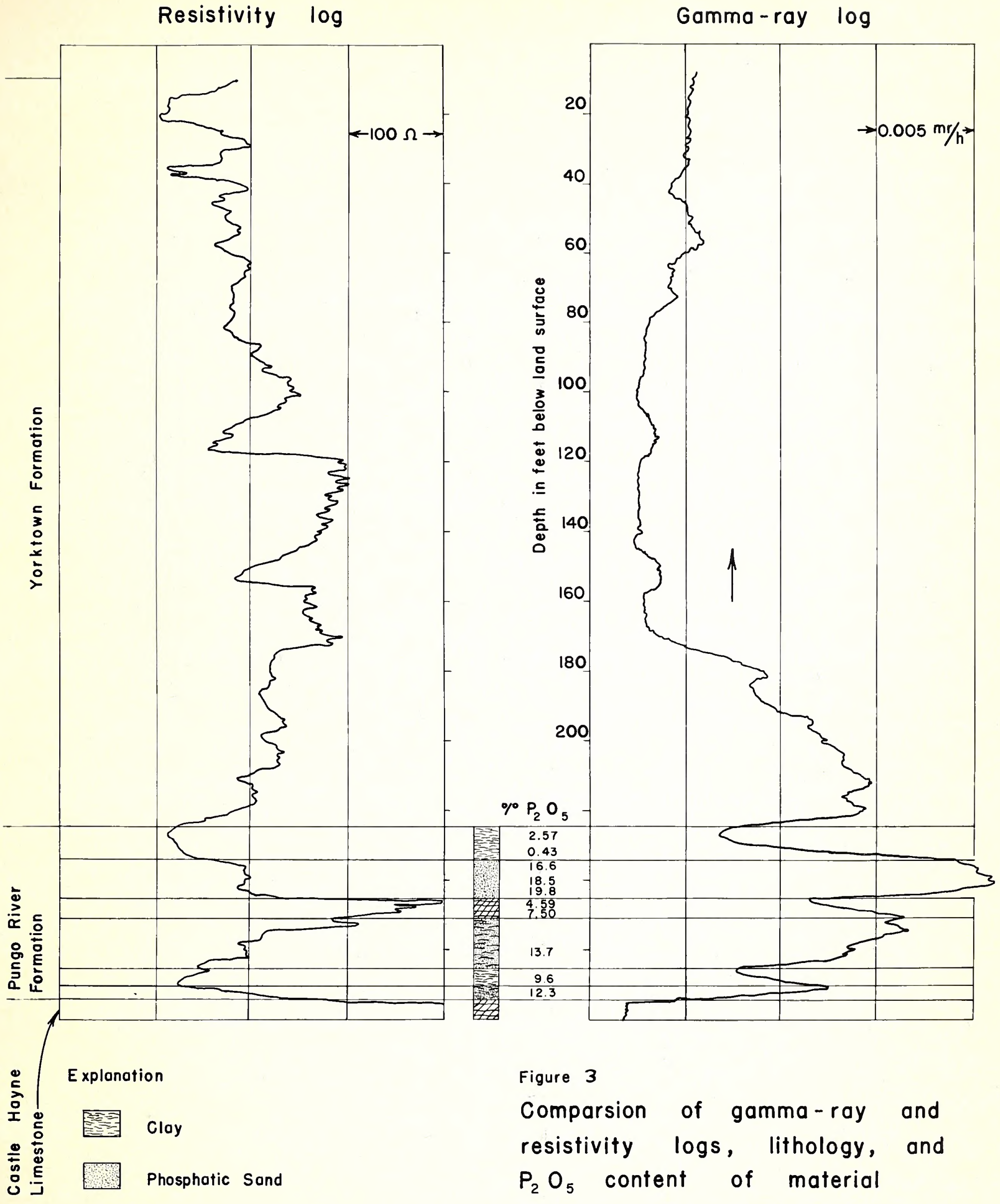
Spontaneous potential logs, normally obtained with resistivity logs, are not included in this report. The relatively shallow depths of the bore holes logged during this investigation usually precluded obtaining smooth, repeating spontaneous potential curves.

Resistivity logs were useful in interpretation of the various lithologic horizons in the Pungo River Formation. Referring again to figure 3, the rocks penetrated by this core hole in order of descending resistivity are limestone, phosphatic sand, clayey phosphatic sand, and clay.

GEOLOGY

Introduction

Most of the Pungo River Formation in Beaufort County underlies the twelve 7½-minute topo-



Explanation

- ▤ Clay
- ░ Phosphatic Sand
- ▨ Limestone
- ▒ Clayey phosphatic sand

Figure 3

Comparsion of gamma-ray and resistivity logs, lithology, and P_2O_5 content of material from a core hole.

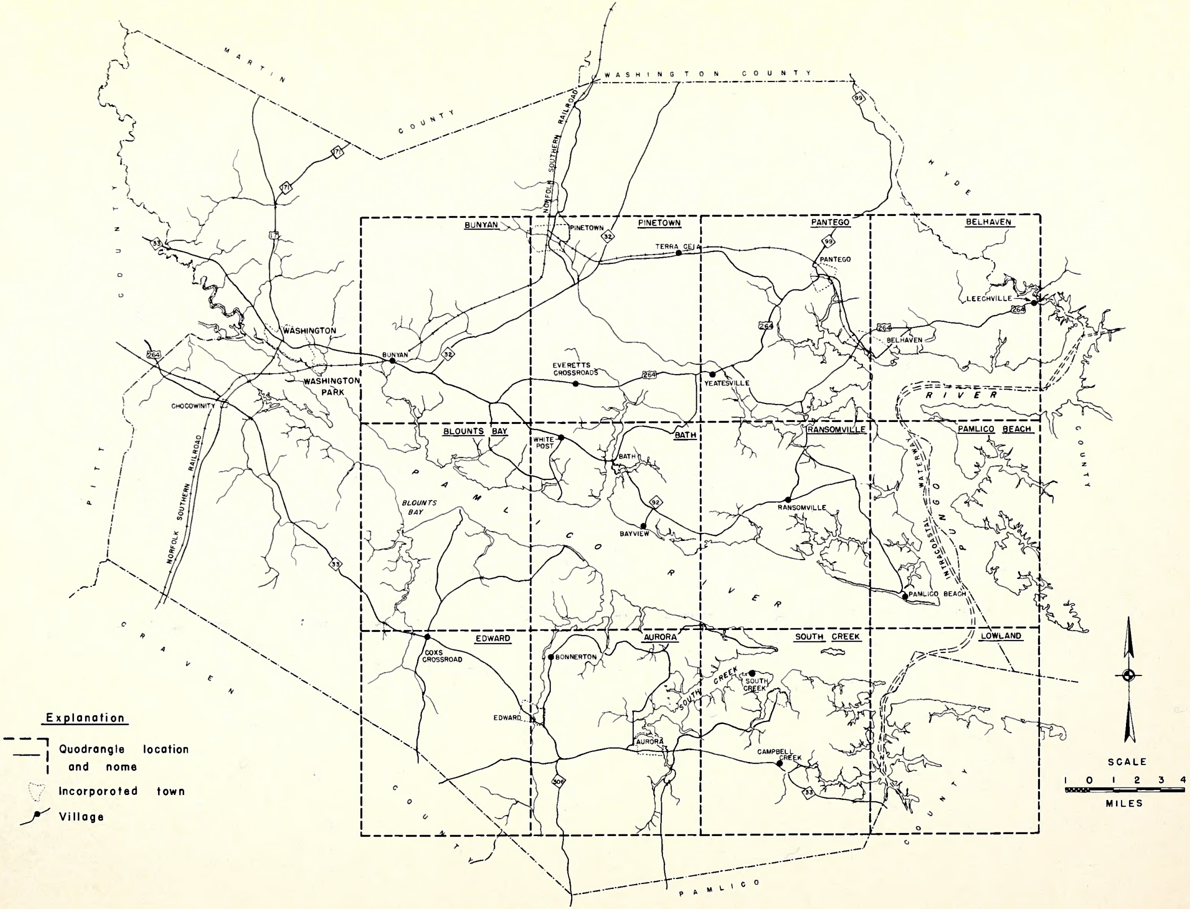


Figure 4: Map of Beaufort County showing location of topographic quadrangles used for base map

graphic quadrangles shown in figure 4. These twelve quadrangles were reduced by one-half in linear dimensions and made into a composite base map (fig. 5) for this report. The Pungo River Formation pinches out to the west as shown in figure 6. From this featheredge, it dips and thickens generally to the east. It underlies small portions of the county beyond the north-central and south-central limits of the base map used here; however, a description of these portions is included in this report.

The Pungo River Formation, of middle Miocene age, unconformably overlies the Eocene Castle Hayne Limestone. It is unconformably overlain by the upper Miocene Yorktown Formation which is unconformably overlain by a thin veneer of Quaternary sediments.

Sediments of Paleocene and Cretaceous age underlie the Eocene Castle Hayne Limestone in Beaufort County. They are not described in this report because few of the wells from which data were collected penetrated these older sediments.

Post-Miocene Sands and Gravels

These surficial deposits are of post-Miocene age and include, in part, material designated by Stephenson (Clark and others, 1912, p. 27) as Pleistocene terraces.

In Beaufort County, these deposits are composed primarily of variegated clays, sandy clays, silty sands, and gravels. Little stratification is apparent except localized crossbedding. The deposits appear to be primarily of nonmarine fulviatile origin. They unconformably overlie the late Miocene Yorktown Formation.

In the area of investigation, the deposits range in thickness from less than five feet to more than 30 feet. There is a slight general thickening trend toward the east but the thicker parts of these deposits occupy present topographic highs or depressions in the erosional surface of the underlying Yorktown Formation.

Yorktown Formation

The name Yorktown Formation was first used in North Carolina by Miller (Clark and others, 1912, p. 229) who correlated late Miocene rocks in eastern North Carolina with the Yorktown Formation of Virginia. In Beaufort County, the formation is composed of gray shell marls, unconsolidated to indurated sandy shell beds, and massive marine clays with interbedded sands. The strata are usually lenticular which precludes lateral tracing of lithologic horizons, particularly of the cleaner sand strata. The basal several feet of the formation contains sand and pebble-sized phosphate grains usually spherical or ovoid in shape; the grain size increases downward. This material apparently represents reworked material from the underlying Pungo River Formation.

The Yorktown Formation is covered by a thin veneer, usually less than 20 feet thick, of undifferentiated clays, sands, and gravels of post-Miocene age. It overlies, unconformably the middle Miocene Pungo River Formation; cobble to boulder-sized pieces of black phosphate rock commonly occur along the unconformable surface. Outcrops of the formation are rare in Beaufort County, usually being confined to stream and road cuts.

The formation ranges in thickness from less than 30 feet in the western part of the area of investigation to more than 290 feet in the eastern part of the county. It dips generally to the east in Beaufort County.

Pungo River Formation

Phosphorite deposits in Beaufort County, N. C., were first formally described by Brown (1958). He designated the phosphorite unit as being of middle Miocene age on the basis of Foraminifera from the upper part of the unit that are correlative with Foraminifera from the middle Miocene Calvert Formation of Maryland. The writer, in 1964, proposed the name, Pungo River Formation, for the phosphorite unit. The name is derived from the Pungo River. The formation is not known to crop out so a core hole near Belhaven in northeastern Beaufort County was designated as the type core hole.

The Pungo River Formation is composed of interbedded phosphatic sands, silts and clays, diatomaceous clays, and phosphatic and nonphosphatic limestones and silty claystones. Lithologic horizons in the formation may be traced laterally across the county and there is usually only small lateral variation in the P_2O_5 content of a horizon. The formation is described in detail in the section entitled "Geology of the Pungo River Formation".

The Pungo River Formation lies unconformably on the Castle Hayne Limestone of Eocene age and is unconformably overlain by the upper Miocene Yorktown Formation. The contact with the overlying Yorktown Formation as observed in well cuttings and cores, is sometimes gradational due to the reworked phosphatic material in the base of the Yorktown Formation.

The thickness of the formation ranges from a featheredge in the western part of the area of investigation to more than 120 feet in eastern Beaufort County as shown in figure 6. The top of the formation dips generally to the east at a rate of about 5 to 10 feet per mile as seen in figures 6 and 7.

Castle Hayne Limestone

The Castle Hayne Limestone was named by Miller (Clark and others, 1912, p. 185) for limestone exposures of late Eocene age near Castle Hayne, New Hanover County, North Carolina. P. M. Brown (1963, oral communication) indicates the Castle Hayne Limestone in Beaufort County, North Carolina, is middle Eocene in age.

The formation is confined to the subsurface in Beaufort County and underlies the entire area of investigation. It consists typically of light to dark-gray limestone, composed principally of shell casts and molds with some light-gray shell limestone, dark-gray dolomitic shell limestone, and interbedded calcareous and noncalcareous sands. The interbedded sands are most common in the southeastern part of the area of investigation. The top of the Castle Hayne Limestone at the contact with the phosphorite unit is usually indurated. A thin zone, usually less than two inches thick, of glossy, dark brown to black indurated phosphate commonly coats the contact surface of the Castle Hayne Limestone.

The thickness of the formation ranges from about 100 feet in the western part of the area of investigation to more than 200 feet in the east. Its depth below sea level ranges from less than 40 feet to more than 300 feet as shown in figure 8. In most of the area of investigation the formation dips generally to the east at a rate of from about 7 to 20 feet per mile.

GROUND-WATER HYDROLOGY

Introduction

A brief discussion of ground-water hydrology is included here in this report because the quantity, quality, and mode of occurrence of ground water in the geologic formations in Beaufort County may have influence on proposed methods for mining the phosphatic sands of the Pungo River Formation.

Most ground water in Beaufort County occurs under artesian conditions; that is, it is confined under pressure. Water enters an artesian aquifer where it crops out or by percolation through overlying or underlying materials. The movement of water in an artesian aquifer is down the hydraulic gradient and recharge water eventually reaches a place in the aquifer that is overlain and underlain by relatively impermeable beds; here the aquifer is filled to capacity and the confined water is subjected to pressure from water updip in the aquifer. The amount of pressure determines the water level in a well that taps the artesian aquifer.

Some ground water in Beaufort County, principally in the surficial deposits of post-Miocene age, occurs under nonartesian, or water-table conditions. Such ground water is subjected to atmospheric pressure rather than the pressure of updip ground water.

An aquifer's capacity to transmit and to store water is governed by its coefficients of transmissibility and storage. The coefficient of transmissibility is defined as the rate of flow of water, in gallons a day at the prevailing water temperature, through each vertical strip of the aquifer one foot wide having a height equal to the thickness of the aquifer, under a unit hydraulic gradient. The coefficient of storage is defined as the volume of water released or taken into storage per unit change in the component of head, normal to that surface.

Hydrologic Properties of the Geologic Formations

Post-Miocene Sands and Gravels

Some domestic water supplies in Beaufort County are obtained from shallow, small diameter wells that withdraw water from the surficial sands and gravels. The yield of such wells is small and the iron content of the water is often excessive for domestic use.

Yorktown Formation

A few wells in Beaufort County withdraw water from the Yorktown Formation. Most of these wells are in the part of the county east of Belhaven where they withdraw water from an indurated shell bed near the base of the formation. Water supplies could be developed from sandy strata within the formation but their random orientation and lenticular nature has largely precluded such development.

Water occurs under artesian conditions in most of the formation. Near the top of the formation, in localized areas, water occurs under water-table conditions. The paucity of information concerning the water-bearing characteristics of the Yorktown Formation in Beaufort County prevents estimates of the quantity and quality of its contained ground water.

Pungo River Formation

The Pungo River Formation is seldom used as an aquifer in Beaufort County. Water supplies could be developed from wells constructed to withdraw water from the cleaner phosphatic sands in the formation but this has been precluded by the relative ease of developing water supplies from the underlying Castle Hayne Limestone. A few wells in Beaufort County withdraw water from the intercalated limestones in the formation; these limestones are relatively thin and will not yield large amounts of water. Water occurs under artesian conditions in the Pungo River Formation, but little data is available concerning the quality of the water or the potential yield of the formation.

Castle Hayne Limestone

This is the principal aquifer in Beaufort County. It contains water under artesian conditions. In the area of investigation the formation is comprised mainly of very permeable cast and mold limestone. Available quantitative data indicates that this aquifer has coefficients of transmissibility that range from about 100,000 to more than 400,000, and a storage coefficient of approximately 0.0002. The yield of wells that tap the Castle Hayne Limestone is dependent primarily upon the depth of penetration in the limestone. Yields of some irrigation wells that penetrate up to 200 feet of limestone are greater than 1,000 gpm (gallons per minute). Few, if any, wells that draw water from the Castle Hayne in the area of investigation are screened. They are commonly constructed by seating the casing in a competent zone in the limestone and then drilling an open hole deeper into the formation. Flowing wells, that tap the Castle Hayne Limestone, are common in most of the area of investigation.

The Castle Hayne Limestone contains fresh water, at least in the upper part of the formation that is usually tapped by wells, throughout most of the area of investigation. In the eastern part of the county, brackish or saline water may be present in the upper part of the formation. Water from the formation is typically hard. Only one water sample analyzed as part of this investigation contained less than 200 parts per million (ppm) hardness; the highest hardness noted was 407 ppm. Water from the Castle Hayne Limestone commonly has a disagreeable odor due to the occurrence of hydrogen sulfide (H_2S) and may contain objectionable amounts of dissolved iron (Fe). The iron content of water samples from the formation analyzed during this investigation ranged between 0.02 and 6.8 ppm.

Relation of Ground Water to Possible Mining Operations

There are two general methods that may be used to mine the phosphatic sands of the Pungo River Formation: (1) hydraulic mining from wells constructed to "pump" sand, and (2) dredging, or some other type of open pit mining.

If ground water is used in a hydraulic mining operation, it could be obtained from wells tapping the Castle Hayne Limestone. However, prolonged withdrawal of excessive quantities of water from this aquifer would probably result in encroachment of salt water because of the high permeability of the aquifer.

In an open pit mining operation a large quantity of water would have to be pumped to maintain a dry pit. This would be particularly true if the mining operation penetrated close to, or into, the Castle Hayne Limestone. Maintaining a dry pit that breached the Castle Hayne Limestone would involve lowering the artesian head more than 100 feet in most of the potential areas of economic phosphorite occurrence. This factor might necessitate the use of wet open-pit methods.

GEOLOGY OF THE PUNGO RIVER FORMATION

Structural Geology

The various lithologic horizons in the Pungo River Formation in Beaufort County are shown in an isometric fence diagram (figure 6). Brown (1958) advanced the hypothesis that the Beaufort County phosphorites were deposited in a northeast-southwest trending basin. Data from the current investigation appear to support Brown's hypothesis and indicate that the Pungo River

Formation was deposited during a transgressive-regressive cycle of the sea into a northeast-southwest trending basin. The axis of the basin apparently lay to the southeast of Beaufort County. Factors in support of this hypothesis include the following:

(1) The formation has a relatively constant thickness in a northeast-southwest direction; that is, a section parallel to the axis of the basin exhibits the expected constant thickness.

(2) Microfaunal analysis supports the transgressive-regressive cycle of deposition of the materials in the formation.

(3) Southeast of Beaufort County, in the deeper part of the basin, available data indicates that the formation is comprised mainly of clay.

Following deposition of the Pungo River Formation, the basin of deposition apparently was downwarped to the southeast. Subsequent erosion beveled the formation on its western side as seen on the fence diagram (figure 6) so that progressively older beds in the Pungo River Formation are in contact with overlying sediments from east to west. At least part of the phosphatic material that was removed by erosion was reworked into the base of the Yorktown Formation that unconformably overlies the Pungo River Formation.

Lithology

The Pungo River Formation contains interbedded phosphatic sands, phosphatic and diatomaceous clays, and indurated limestones, coquinas and claystones.

The phosphatic sands of the formation are comprised of fine to medium-grained collophane and quartz with varying percentages of silt and clay sized material, small phosphatized fish teeth and bone fragments. The collophane grains are typically smooth, glossy, brown in color, and spheroidal to ovate in shape. Surfaces of individual grains commonly show concentric rings or bandings. Pebble-sized phosphate grains (+20 mesh) normally comprise less than 10 percent volume of the phosphatic sands. The quartz occurs typically as clear, flat sided, angular to subrounded grains. Accessory minerals in the phosphatic sands include apatite, calcite and garnet. The more clayey phosphatic sands often contain weathered shell material.

The clays are principally phosphatic and diatomaceous clays; there are some calcareous clays in the formation. The phosphatic clays are often silty; they are brown to olive green in color. Often, when drying, they develop a shaly fissility. The diatomaceous clays are light gray in color, they are composed of up to 90 percent diatom shells and fragments in a silt to clay sized groundmass. The calcareous clays are usually light green to light gray to white in color.

Indurated zones in the formation include several rock types: phosphatic limestones, silty claystones, and coquinas. The phosphatic limestones are usually dolomitic and gray to dark gray in color. Typically, they are dense limestones that contain varying amounts of quartz, sand and pebble phosphate. They contain shell imprints and occasionally, calcareous shell material. Locally, this rock is composed entirely of dolomitic cast and mold limestone. The phosphatic limestones that are well indurated are very competent rocks. The well indurated rocks grade both laterally and vertically into poorly indurated rocks so that competent zones usually have a limited lateral extent. The silty claystones, derived from cementation of the phosphatic clays, are usually light to dark gray in color. Usually, their occurrence is localized and they grade both laterally and vertically in the phosphatic clays. Typically, they are friable, but locally are well cemented and competent. The occurrence of coquinas in the section is confined in Beaufort County, except locally, to the south side of the Pamlico River. The coquinas, creamy white to light gray in color, are composed of shell fragments, whole shells, and recrystallized calcite; very locally, they contain significant amounts of pebble and cobble sized phosphate. They vary in degree of induration from very poorly cemented to well cemented, competent rocks. The coquinas are interbedded with calcareous clays that are white to light gray and greenish yellow in color. Occasionally diatomaceous clays are interbedded with the coquinas and calcareous clays.

In the following section the areal extent, thickness, variation in lithology, and P_2O_5 content of the above described rocks that constitute the Pungo River Formation in Beaufort County are discussed.

SYSTEMATIC DESCRIPTION OF THE PUNGO RIVER FORMATION

Introduction

In this section, the lithology and P_2O_5 content of the various materials in the Pungo River Formation are described for each topographic quadrangle comprising the base map (fig. 5). The relatively small geographical area comprised by each quadrangle facilitates description of the formation throughout the county with minimum confusion. Accordingly the characteristics of the formation, as it underlies each quadrangle, are discussed in order from north to south and east to west; that is, the description begins with the Belhaven quadrangle in the northeast and ends with the Edward quadrangle in the southwest portion of the area. Description of the formation in some peripheral areas of the county, that are excluded from the base map, is included in the description of the adjacent quadrangle on the base map.

Criteria Used on Fence Diagram

Figure 6 is an isometric fence diagram of the Pungo River Formation in Beaufort County. The lithology and P_2O_5 content of the sediments are combined in the fence diagram. This combination was effected by grouping the previously described lithologic materials of the formation into four classifications that, in most cases, implies both their lithology and P_2O_5 content. These four classifications and their lithologic and P_2O_5 content implications are as follows:

High grade phosphatic sand—This classification includes phosphatic sands in the formation that have an arbitrarily selected P_2O_5 content of greater than 14 percent of the raw core sample. This material is composed of sand-sized collophane and quartz grains with varying amounts of silt-sized particles.

Phosphatic sand—This classification includes the phosphatic sands of the formation that have an arbitrarily selected P_2O_5 content of from 10 to 14 percent of the raw core sample. Lithologically, the material of this classification is similar to the material classified as high grade phosphatic sand; it differs only in containing more clay and/or quartz sand which decreases its P_2O_5 content. The clay content becomes dominant in the lower grade material of this classification.

Clay—This classification includes the clays and the more clayey phosphatic sands of the formation. Their P_2O_5 content is less than 10 percent.

Indurations—This classification includes the phosphatic limestones, silty claystones, and coquinas of the formation. Their P_2O_5 content is not implied by this classification but rarely, and only very locally, does it exceed 10 percent.

The lithologic names that apply to the classifications as defined above will be used in the remainder of this report.

Belhaven Quadrangle

In the Belhaven quadrangle, the thickness of the Pungo River Formation ranges from about 30 feet at the northwest corner of the quadrangle to more than 60 feet on the eastern side. Its depth below mean sea level ranges from about 180 feet at the Hyde County line in the northwestern part of the quadrangle to about 225 feet at the east-central portion of the quadrangle.

A typical composite section from top to bottom of the formation in the Belhaven quadrangle is as follows:

(1) Ten to 15 feet of clay, the upper part of this zone is a dark brown, shaly, phosphatic clay; the lower part of the zone is light gray diatomaceous clay.

(2) Ten to 12 feet of high grade phosphatic sand, dark olive brown in color. The upper one foot, or so, is interbedded with the overlying clay. The P_2O_5 content of this zone ranges between about 15 and 20 percent; it is usually highest at the bottom of the zone.

(3) Nine to 11 feet of phosphatic limestone. The top of the zone is usually well cemented but the lower several feet are often less well cemented and contain unconsolidatd zones. There are cast and mold limestones in this zone that are permeable enough to cause loss of drilling mud circulation.

(4) Ten to 18 feet of phosphatic sand. This zone is lighter colored, contains more quartz sand, and is lower in P_2O_5 content than zone (2). Its P_2O_5 content ranges from about 10 to 14 percent P_2O_5 and is estimated to average about 12 percent. The relatively high percentage of quartz sand in this zone makes a high rate of core recovery difficult.

(5) Six to ten feet of clay, in part diatomaceous. The phosphatic clay in this zone is lighter colored and more silty than in zone (1). It is sometimes cemented into a silty claystone.

(6) Two to seven feet of phosphatic limestone that sometimes contains thin interbedded phosphatic sands. The phosphatic sand in this zone is often cemented and contains more pebble-sized

phosphate than is common in the Pungo River Formation.

The above zones extend to and beyond the county line in the small portion of Beaufort County that is east of the Belhaven quadrangle.

The thinning of the unit in the northwestern part of the quadrangle is due to erosion. In the extreme northwest corner (fig. 6), erosion has removed zones (1) and (2). Here the top of the unit is the phosphatic limestone of zone (3).

The zones described above are horizons that make up the Pungo River Formation throughout Beaufort County although in some areas, they have pinched out, been removed by erosion, or have undergone facies change. The zone-numbering system will be used, insofar as possible, in the description of the other quadrangles.

Pamlico Beach Quadrangle

Approximately the western one-third of the Pamlico Beach quadrangle is in Beaufort County. The Pungo River Formation is about 55 feet thick at the northwest corner of the quadrangle; it thickens to about 90 feet in the vicinity of Wades Point which is in the south-central part of the quadrangle near the Hyde County line. Its depth below mean sea level ranges from about 160 feet in the southwestern corner of the quadrangle to about 190 feet in the northeastern corner.

All the zones that occur in the formation in the Belhaven quadrangle are present in the Pamlico Beach quadrangle. The upper clay zone (1) is at the top of the formation. In the northern part of the quadrangle it is composed entirely of phosphatic and diatomaceous clays; in the southern part of the quadrangle it contains significant amounts of interbedded calcareous clays, coquinas and phosphatic sand and pebbles. Zone 1 is thickest (about 25 feet) at the west-central edge of the quadrangle (figure 3).

The high grade phosphatic sand zone (2) that underlies the clay zone, thickens from about eight feet in the northeastern portion of the quadrangle to about 12 feet near Wades Point. The $P_2 O_5$ content of the zone ranges from about 15 to slightly more than 20 percent. The thickness of the phosphatic limestone zone (3) that underlies the high grade phosphatic sand zone ranges from two feet to about five feet; it is thinnest near Wades Point.

Phosphatic sand (zone 4) underlies the phosphatic limestone. Its thickness and $P_2 O_5$ content increases in the southern and southwestern part of the quadrangle. Its $P_2 O_5$ content increases from about 13 percent in the northwestern part of the quadrangle to as much as 20 percent near the southwestern part of the quadrangle. The increase in $P_2 O_5$ content to the southwest is caused by a decrease in quartz sand content. Its maximum thickness is about 30 feet near Wades Point. Locally, in this area, it contains clay beds and phosphatic limestones up to about five feet thick.

The phosphatic sand zone is underlain by a clay zone (5) that is up to 20 feet thick. This clay zone contains both phosphatic and diatomaceous clays. Locally, the phosphatic clay has been cemented into silty claystones.

Underlying the basal clay zone in part of the quadrangle is a zone of phosphatic limestone (6) that is as much as five feet thick.

Lowland Quadrangle

The Lowland quadrangle, while included on the base map, is not discussed here because only a small part of the land area of the quadrangle lies in Beaufort County and there is no available data concerning the Pungo River Formation in that limited area.

Pike Road Quadrangle

The Pike Road quadrangle, directly north of the Pantego quadrangle, is not included on the base map. The southern two-thirds of the quadrangle is in Beaufort County.

The depth below mean sea level of the Pungo River Formation ranges from about 120 feet in the southwestern part of the quadrangle to about 160 feet in the east-central part. The thickness of the formation ranges from about 20 feet in the west-central portion of the quadrangle at the Hyde County line to about 45 feet at the east-central side of the quadrangle.

In most of the Pike Road quadrangle, the phosphatic limestone (zone 3) that is near the middle of the formation in the Belhaven quadrangle is at the top of the formation. Erosion has stripped the upper part of the formation although there are outliers, up to six feet thick, of high grade phosphatic sand on top of the limestone (fig. 6). The phosphatic limestone is from four to about 12 feet thick, it is thickest in the southeastern part of the quadrangle. A phosphatic sand zone (4) underlies the phosphatic limestone. It thickens from about five feet on the western side of the quadrangle to about 11 feet on the eastern side of the quadrangle. The P_2O_5 content of this zone decreases from about 15 percent on the western side of the quadrangle to less than 11 percent on the eastern side. An increase in clay content of the phosphatic sand causes this decrease in grade.

Light brown phosphatic clay (zone 5) underlies the phosphatic sand. It thickens from about four feet on the western side of the quadrangle to about 14 feet on the eastern side. Some zones in the clay are indurated into a silty claystone.

Zone 6, the basal phosphatic limestone, is present only in the southeastern part of the Pike Road quadrangle where it is two to three feet thick.

The zones described above extend east of the Pike Road quadrangle to, and beyond, the Hyde County line.

Pantego Quadrangle

The Pungo River Formation underlying the southeastern part of the Pantego quadrangle contains all the zones that underlie most of the Belhaven quadrangle. But to the north and west, the upper part of the formation has been stripped off by erosion. The upper clay zone (1) has been eroded away in the northern, central and west-central portions of the quadrangle. In these portions, varying thicknesses of high grade phosphatic sand are at the top of the formation except for the area near Pantego (shown on the fence diagram) where all the high grade phosphatic sand has been stripped away and the phosphatic limestone of zone 3 is at the top of the formation.

The thickness of the phosphatic limestone ranges between about three to eight feet in the Pantego quadrangle. It shows little lateral trend in thickening or thinning.

Underlying the phosphatic limestone is from four to 12 feet of phosphatic sand (zone 4). This zone thickens generally from west to east and there is a gradual decrease in P_2O_5 content from almost 14 percent on the western side to about 12 percent on the eastern side.

A clayey zone (5), in part diatomaceous and in part indurated, underlies the phosphatic sand zone. The thickness of the clay zone ranges from about 10 feet in the southwestern part of the quadrangle to more than 20 feet in the east-central part of the quadrangle.

Zone 6, the phosphatic limestone, underlies zone 5 in part of the southern and eastern portions of the quadrangle. It ranges up to about eight feet in thickness.

The top of the formation is about 125 feet below mean sea level in the west-central part of the quadrangle. It has a maximum depth of about 190 feet in the northeastern part of the quadrangle. The formation is thinnest (25 feet) in the west-central part of the quadrangle and thickest (45 feet)in the east-central part.

Ransomville Quadrangle

In the Ransomville quadrangle the Pungo River Formation thickens from about 35 feet in the north-central and northwestern parts of the quadrangle to about 75 feet in the southeastern part of the quadrangle. The depth of the formation below mean sea level ranges from about 110 feet in the southwestern part of the quadrangle to about 180 feet in the northeastern portion.

The upper clay zone (1), composed of phosphatic and diatomaceous clays, is at the top of the unit over the entire quadrangle area. This zone is thickest in the north-central part of the quadrangle where it is more than 35 feet thick.

The high grade phosphatic sand zone (2) underlies the upper clay zone. Its thickness varies from less than four feet on the west-central side of the quadrangle to about 15 feet, locally, along the north shore of the Pamlico River. For the entire quadrangle, the thickness of this zone averages about six feet; its P_2O_5 content ranges from slightly more than 14 to about 18 percent.

In most of the quadrangle a phosphatic limestone zone (3) forms a continuous horizon that underlies the high grade phosphatic sand. Its thickness ranges from about three to almost 10 feet. There is no constant directional trend in its thickening and thinning. Locally, this zone is absent in the southern part of the quadrangle by the north shore of the Pamlico River.

Phosphatic sand (zone 4) underlies the phosphatic limestone. It thickens generally from north to south in the Ransomville quadrangle. Its minimum thickness is less than five feet in the northeastern part of the quadrangle; its maximum thickness is about 25 feet in the southeastern part of the quadrangle. Its P_2O_5 content also increases to the southeast. Here it is locally as high as 17 percent, whereas over most of the quadrangle it averages about 12 to 14 percent. The thicker parts of this zone locally contain thin interbedded clays and indurated zones.

Zone 5, composed of phosphatic and diatomaceous clays, is present throughout the entire quadrangle though, locally, its entire thickness has been cemented. This zone is thickest near the west-central edge of the quadrangle where it is more than 20 feet thick.

In most of the quadrangle, the phosphatic limestone of zone 6 underlies the above clay. Its maximum thickness is less than five feet and it is absent in the northwestern and southeastern parts of the quadrangle.

South Creek Quadrangle

The Pungo River Formation is from about 105 to about 150 feet below mean sea level in the South Creek quadrangle. The minimum depth is in the northwest corner, the maximum in the northeast. The formation thickens from about 70 feet in the northwest corner to about 115 feet in the southeast corner.

Zone 1, the upper clay zone defined in the discussion of the Belhaven quadrangle is the top of the formation in the South Creek quadrangle. On the south side of the Pamlico River this zone is composed of interbedded coquinas, phosphatic diatomaceous and calcareous clays, and sand and pebble-sized phosphate. The coquinas are competant rocks locally but they grade both laterally and vertically into less competant coquinas and calcareous clays. The phosphatic sand and pebble beds are usually less than two to three feet in thickness. Their P_2O_5 content is often greater than 14 percent but their limited lateral continuity and thickness appears to make them of little economic interest. Zone 1 is thinnest (about 15 feet) in the northwestern corner of the quadrangle; it thickens to more than 30 feet in the southeastern part of the quadrangle.

Zone 2, the high grade phosphatic sand, underlies the interbedded coquinas and clays of zone 1 except in the east-central and southern parts of the quadrangle where clay is predominant in the section. The P_2O_5 content of the material in this zone decreases to the south and east; its maximum, along the west edge of the quadrangle is about 17 percent. The zone contains thin, interbedded, clays and silty claystones. The maximum thickness of this zone is about 30 feet in the north-central part of the quadrangle.

The phosphatic sand of zone 4 underlies the high grade phosphatic sand in the northern, western, and central parts of the quadrangle. Its maximum thickness is about 25 feet in the west-central portion of the quadrangle. It is absent except locally in the southern and eastern parts of the quadrangle where the unit is composed largely of clay. The P_2O_5 content of the phosphatic sands ranges between about 11 and 14 percent.

Phosphatic and calcareous clays underlie zone 4 in all of the quadrangle. They contain interbedded clayey siltstones.

Available data indicates that in the small portions of Beaufort County, that lie east and south of the South Creek quadrangle, the Pungo River Formation is composed largely of clays and indurated zones.

Pinetown Quadrangle

The erosional thinning trend of the Pungo River Formation continues in a westerly direction across the Pinetown quadrangle. The formation thickens from about 15 feet at the northwest corner of the quadrangle, where it is composed entirely of phosphatic limestone and clay, to a thickness of about 35 feet in the southeastern and eastern parts of the quadrangle. Its depth below mean sea level ranges from about 75 feet in the northwestern part of the quadrangle to about 125 feet in the northeastern part.

In the extreme southeastern part of the quadrangle, the upper clay zone (1) forms the top of the formation. In the northern and northwestern parts of the quadrangle phosphatic limestone is at the top of the formation.

The thickest section of potentially economic phosphate in the Pinetown quadrangle is near the center of the quadrangle (fig. 6). Here there is about 20 feet of phosphatic sand that averages about 15 percent P_2O_5.

Bath Quadrangle

The Pamlico River divides the Bath quadrangle into a northern and southern part.

The Pungo River Formation ranges in depth below mean sea level from about 65 feet in the southwestern part of the quadrangle to about 125 feet in the northeastern part.

On the north side of the river, the formation thickens from about 15 feet at the west edge of the quadrangle to about 50 feet at the eastern edge. The phosphatic and diatomaceous clay zone (1) is at the top of the formation on the northeastern part of the quadrangle; it is absent to the west and south. It is thickest (about 27 feet) near the northeastern corner of the quadrangle.

The clay zone is underlain by a thin (one to five foot thick) zone (2) of high grade phosphatic sand. The P_2O_5 content ranges from 14 to more than 18 percent. Near the north shore of the Pamlico River on the eastern portion of the quadrangle, zone 2 is at the top of the unit.

A phosphatic limestone zone (3) underlies the high grade phosphatic sand zone in the areas where the phosphatic sand zone is present. On the western side of the quadrangle, zone 3 is the top of the unit. This zone is from three to seven feet thick.

Another high grade phosphatic sand zone (4) underlies the phosphatic limestone. Its P_2O_5 content averages about 16 percent. It is thickest (about 13 feet maximum) near the north shore of the Pamlico River (figure 6).

A zone of phosphatic clay (5) underlies the above described phosphatic sand zone. Parts of this zone are indurated into silty claystones. The zone is thickest (about 20 feet) near the north shore of the river.

On the south side of the Pamlico River, the upper part of the formation in the Bath quadrangle is composed of coquina interbedded with calcareous and diatomaceous clays. This coquina zone is the stratigraphic equivalent of the upper clay zone (1) on the north side of the river. The zone is about 18 feet thick in the southeast corner of the quadrangle. It thins to a featheredge on the western side.

A high grade phosphatic sand zone (2) underlies the coquina. Its P_2O_5 content averages 16 to 18 percent. It thickens from west to east and is 10-12 feet thick at the southeast corner of the quadrangle.

The phosphatic limestone (zone 3) that underlies the above horizon on the north side of the Pamlico River is absent, except locally, on the south side of the river. In the areas where it is absent the high grade phosphatic sand is underlain by a phosphatic sand zone (4) that averages 11 to 13 percent in P_2O_5 content. This lower grade zone contains a higher percentage of clay than the overlying high grade phosphatic sand zone. The phosphatic sand zone ranges in thickness from about 15 feet on the western side of the quadrangle to about 25 feet in the southeastern corner of the quadrangle.

The phosphatic sand zone is underlain by a phosphatic clay zone (5) that is sometimes indurated into a silty claystone. Its thickness has little lateral trend on the Bath quadrangle; its maximum thickness is about 10 feet.

Aurora Quadrangle

The depth below mean sea level to the Pungo River Formation in the Aurora quadrangle ranges from about 30 feet in the northwestern part of the quadrangle to about 100 feet in the southeastern part.

The coquina zone (1), composed of interbedded coquinas, diatomaceous and calcareous clays, is at the top of the formation in most of the Aurora quadrangle. The clays are usually predominant in the top of the zone although they are often prominent in the center and bottom of the zone. The coquinas vary in color from almost white to light grayish green in color and vary in degree of induration from very friable, poorly cemented rocks to well cemented, competent rocks. The thickness of the coquina zone ranges from a featheredge in the northwestern corner of the quadrangle to more than 35 feet in the southeastern corner.

High grade phosphatic sand (zone 2) underlies the coquina. In the northern half of the quadrangle, it pinches out to the west and northwest, thickens to a maximum thickness of about 35 feet in the central part of the quadrangle, and thins to about 10-12 feet in the east and northeast. In the southern half of the quadrangle, this zone is about 10 feet thick in the southwest, central and east-central parts of the quadrangle; it is missing entirely in the southeast corner of the quadrangle. The P_2O_5 content of this zone ranges between about 14 and 18 percent.

The high grade phosphatic sand zone is underlain by a clayey, lower grade, phosphatic sand zone (zone 4). This zone is absent in the north-central part of the quadrangle where the high grade phosphatic sand zone is thickest (figure 6). It thickens to the west and southwest to a maximum thickness of about 25 feet, to the east to a maximum of about 20 feet, and pinches out in the southeastern corner of the quadrangle. Its P_2O_5 content ranges from 10 to 14 percent.

Phosphatic clay (zone 5) underlies the phosphatic sand zone. Parts of this zone are cemented and well indurated, locally it contains intercalated phosphatic sands. Across the northern part of the quadrangle, this zone maintains a thickness of 10-15 feet. It thickens generally to the south and reaches a maximum thickness of about 65 feet in the southeastern corner of the quadrangle where, with the upper coquina zone, it comprises almost the entire formation.

Bunyan Quadrangle

The Pungo River Formation is composed primarily of clay in the Bunyan quadrangle. The clay is a light brown to light greenish brown silty clay. Some phosphatic sands occur in the unit in the southern part of the quadrangle. They have a maximum thickness of less than 10 feet. They are typically clayey and their P_2O_5 content averages less than 14 percent.

The unit pinches out on the western side of the quadrangle. It thickens to the east and is about 25 feet thick in the east-central portion of the quadrangle. Its depth below mean sea level ranges from about 40 feet in the western part of the quadrangle to about 80 feet in the eastern part.

Blounts Bay Quadrangle

The Blounts Bay quadrangle is split by the Pamlico River. The Pungo River Formation pinches out along the western side of the quadrangle. Its depth below mean sea level ranges from about 40 feet in the western part of the quadrangle to about 90 feet in the southeastern part.

On the north side of the Pamlico River the unit thickens from a featheredge on the west to about 15 feet on the eastern side of the quadrangle. On the western side it is composed mainly of clays and clayey phosphatic sands. On the eastern side, phosphatic sand zones up to 10 feet thick occur (fig. 6); their P_2O_5 content averages less than 14 percent.

On the south side of the Pamlico River the formation thickens to the east from a featheredge to a thickness of about 20 feet. In the east, there is up to 15 feet of phosphatic sand at the top of the formation; the P_2O_5 content averages 12 to 14 percent. This zone is underlain by five feet or more of clay.

Edward Quadrangle

The Pungo River Formation pinches out along the western side of the Edward quadrangle. It thickens to the east and southeast and reaches a maximum thickness of about 50 feet in the extreme southeastern part of the quadrangle. Its depth below mean sea level ranges from about 50 feet in the northwestern part of the quadrangle to about 110 feet in the northeastern part.

The upper part of the formation is composed of phosphatic sand that averages about 11 to 13 percent P_2O_5. The maximum thickness of this zone is in the northeastern corner of the quadrangle where it is up to 20 feet thick. This zone thins rapidly to the south and west (figure 6).

The phosphatic sand zone is underlain by a clay that is slightly phosphatic and light brown to brownish in color. The clay zone is thickest in the southeastern part of the quadrangle where its maximum thickness is about 35 feet; the lower several feet of the clay is often indurated.

ECONOMIC GEOLOGY

The economics of mining a particular phosphate deposit are dependent largely upon the costs of the mining, beneficiation, and marketing operations that are necessary to render raw phosphate ore into a salable form and transfer it to the consumer. The costs of these operations are influenced by several factors which include the following:

(1) The P_2O_5 content of the ore, this is usually expressed as percentage of bone phosphate of lime — this is abbreviated as BPL and derived by multiplying the P_2O_5 percentage by 2.185.

(2) The physical nature of the ore; that is, whether consolidated or unconsolidated rock and the percentage of included waste material.

(3) The chemical nature of the ore and included impurities; that is, the chemical form of the phosphate bearing mineral and the percentage of combined total iron and aluminum.

(4) The thickness and physical nature of overburden that must be penetrated or removed to mine the ore.

(5) The thickness of the ore zones and the amount of recoverable material in these zones.

(6) The geographic location of the deposit.

The influence of some of the above factors were beyond the scope of this investigation. For example, mining methods that may be used to mine the Beaufort County phosphorites would be unique to these deposits in some respects. This precludes preliminary determination, for example, of the maximum thickness of overburden that could be tolerated by different mining methods. Thus the absolute economics of the Beaufort County phosphorites are dependent upon data from pilot mining and beneficiation operations and marketing studies. Consequently, this report has been concerned with describing the lithology, mineralogy, thickness and depth below land surface of the materials in the phosphorite unit. The available beneficiation data for core samples are included in the "Basic Data" section of this report.

SUGGESTIONS FOR FUTURE PROSPECTING

The stratigraphic horizons in the Pungo River Formation trend northeast-southwest across Beaufort County. Their depth below sea level becomes progressively greater to the northeast. The formation extends to the south, east, and north of Beaufort County; its lateral extent in these directions is, at present, unknown.

To complement the description of the formation in Beaufort County, geophysical and lithologic data from adjacent counties were examined. The following conclusions concerning the lithic character, thickness and depth of the formation beyond the boundaries of Beaufort County were drawn from interpretation of the available data:

(1) The formation decreases in thickness and depth below sea level to the south in Craven and Pamlico counties. The thickness and grade of phosphatic sand horizons also decreases to the south and limestones, sandstones, and clays become predominant in the formation.

(2) The formation thickens and is buried progressively deeper to the southeast in Hyde and Pamlico counties; the phosphatic sands pinch out and the formation is composed primarily of clay. Available data indicates that most of the phosphatic sand horizons are pinched out within a short distance southeast of a line passing through Wades Point and the easternmost tip of Beaufort County near Leechville. However, a portion of Hyde County is northwest of this line and this part may merit exploration.

(3) The formation plunges to the northeast but its thickness remains relatively constant. Available data indicates that the thickness and lithic character of horizons in the formation may also remain relatively constant for at least several miles northeast into Hyde County from the easternmost part of Beaufort County.

BASIC DATA

Introduction

The basic data included in this section is of three types: (1) lithologic logs of material from core holes with included laboratory values for P_2O_5 content of the material as available, (2) laboratory beneficiation data for core samples of phosphatic sand, and (3) copies of selected gamma-ray and resistivity logs that were obtained during this investigation.

The numbering system for the location of the basic data points is keyed to the base map (fig. 5). On the base map, the data points are numbered consecutively from north to south by quadrangle. The letters that follow the numbers indicate the type of information available for this point; ie, the letter G indicates a gamma-ray log, R indicates a resistivity log, and L indicates a lithologic log. Combinations of these letters are used if applicable at a particular data point. The abbreviations of the quadrangle names are shown on the base map. On the logs included as basic data the quadrangle abbreviation precedes the numbers and letters to further locate the data points; this is implied, but not shown, on the base map for the sake of convenience. To clarify the above, the data point shown on the Bunyan quadrangle of the base map as 10-GRL indicates that gamma-ray, resistivity, and lithologic logs from this point are included in this section coded as BU-10-GRL.

Lithologic Logs

The lithologic logs of core holes drilled during this investigation are included below. The P_2O_5 content of the raw core sample is included where available.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
120′0″-122′6″	1.13	Diatomaceous clay, light-green; 70 percent light-green very light-weight calcareous clay, 20 percent of sample is composed of diatoms, 10 percent very fine to fine white broken shell fragments. Trace of fine-grained dark-brown to black phosphate, medium subrounded clear to frosted quartz sand. Foraminifera abundant, sponge spicules and shark's teeth rare, no Ostracoda.
122′6″-125′0″	1.98	Clay and shell, light-green; 60 percent light-green light-weight calcareous clay, 20 percent fine to medium white broken shell fragments, 10 percent of sample is composed of diatoms, 10 percent fine to medium-grained dark-brown to black phosphate, 10 percent fine to medium subangular to subrounded clear quartz sand. Fine to medium-grained subangular to subrounded smoky quartz prominent. Foraminifera abundant, sponge spicules rare, no shark's teeth or Ostracoda.
125′0″-125′6″	1.45	Limestone, light greenish-gray; very fine crystalline light greenish-gray poorly indurated limestone. Fine-grained dark-brown to black phosphate and fine to medium subangular to subrounded clear quartz sand prominent. Trace of very fine to fine white broken shell fragments. Foraminifera, sponge spicules, and diatoms common, no Ostracoda.
125′6″-126′9″	1.21	Limestone, light greenish-gray; 80 percent very fine crystalline light greenish-gray well indurated limestone, 10 percent fine-grained dark-brown to black phosphate, 10 percent fine to medium subangular to subrounded clear to frosted quartz sand. Trace of rose quartz, smoky quartz, very fine to fine white broken shell fragments. Foraminifera and diatoms very rare, no sponge spicules or Ostracoda.
126′9″-128′2″	4.08	Sandy limestone, medium greenish-gray, well indurated; 40 percent very fine crystalline medium greenish-gray limestone matrix, 30 percent fine to medium subangular to subrounded clear to frosted quartz sand, 15 percent light-brown to black phosphate, 15 percent very fine to medium white broken shell fragments. Trace of coarse-grained light to dark-gray phosphate, coarse subangular to subrounded frosted quartz sand. Foraminifera rare, no Ostracoda.
128′2″-129′4″	3.08	Sand and clay, medium greenish-gray; 70 percent medium subangular to subrounded clear quartz sand, 20 percent dark greenish-gray clay, 10 percent fine to medium white broken shell fragments. Fine to medium-grained dark-brown to dark-gray phosphate prominent. Trace of coarse-sand to fine-gravel-size aggregates of light-gray limestone and phosphate. Foraminifera common, no Ostracoda.
129′4″-132′6″	1.94	Clay, shell, and limestone, light-gray to white; 40 percent light-gray calcareous clay, 40 percent fine to coarse white broken shell fragments, 20 percent fine to medium-sand-size particles of very fine crystalline light-gray limestone. Fine to medium subangular to subrounded frosted quartz sand prominent. Trace of fine-grained dark-brown to black phosphate, rose quartz. Foraminifera common, Ostracoda rare.
132′6″-135′0″	4.23	Phosphatic limestone, greenish-white, poorly indurated; 60 percent very fine crystalline white poorly indurated limestone matrix, 20 percent very fine to fine-grained dark-brown to black phosphate, 10 percent fine to medium white broken shell fragments, 10 percent fine to medium subangular to subrounded clear quartz sand. Trace of rose quartz. Foraminifera and Ostracoda rare.
135′0″-137′0″		No sample.
137′0″-147′5″	3.01	Sand, medium-gray; 70 percent fine to medium subangular to subrounded clear quartz sand, 15 percent very fine to medium white broken shell fragments, 10 percent medium to light-gray clay, 5 percent fine to medium-grained dark-brown to black phosphate. Trace of smoky quartz, coarse-sand to fine-gravel-size aggregates of light-gray limestone and phosphate, medium angular to subangular clear quartz sand. Foraminifera common, sponge spicules rare, no Ostracoda.
147′5″-148′3″	5.22	Clay, sand, and shell, light greenish-gray; 40 percent very fine to coarse white broken shell fragments, 30 percent light greenish-gray to white calcareous clay, 20 percent fine to medium subangular to subrounded clear quartz sand, 10 percent fine to medium-grained dark-brown to black phosphate. Trace of coarse subangular clear quartz sand. Foraminifera common, sponge spicules rare, no Ostracoda.
148′3″-150′9″	1.15	Calcareous clays and shell, greenish-white; 65 percent greenish-white to white highly calcareous clay, 20 percent very fine to coarse white broken shell fragments, 15 percent fine-sand-size particles of white limestone. Very fine-grained dark-brown to black phosphate and very fine angular to subangular clear quartz sand prominent. Foraminifera common, sponge spicules and diatoms rare, no Ostracoda.

North Carolina State Library
Raleigh

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
150′9″-151′0″	3.19	Phosphatic limestone, greenish-white; 80 percent microcrystalline white to greenish-white poorly indurated limestone matrix, 20 percent very fine to fine-grained light to dark-brown phosphate. Trace of fine angular to subangular clear quartz sand, coarse light-gray to white broken shell fragments, smoky quartz. Foraminifera, diatoms, sponge spicules, and Ostracoda rare.
151′0″-151′11″	3.27	Phosphatic limestone, greenish-white; 60 percent microcrystalline white well indurated limestone matrix, 25 percent very fine to medium-grained light-brown to dark-gray phosphate, 15 percent very fine to fine angular to subangular clear quartz sand. Fossil casts and molds very prominent. Trace of coarse-grained, dark-brown phosphate, rose quartz. Foraminifera, sponge spicules, diatoms, and Ostracoda rare.
151′11″-154′2″	15.5	Phosphatic sand, medium greenish-brown; 55 percent very fine to fine angular to subangular clear quartz sand, 45 percent very fine to fine-grained light to dark-brown phosphate. Trace of coarse-grained light to dark-brown phosphate, medium to coarse subangular clear to frosted quartz sand, medium white broken shell fragments. Foraminifera and sponge spicules very rare, no diatoms or Ostracoda.
154′2″-158′1″	14.6	Phosphatic sand, medium greenish-brown; same as 151′11″-154′2″ interval with Formanifera very rare, no sponge spicules or Ostracoda.
158′1″-159′1″		No sample.
159′1″-161′5″	13.5	Phosphatic sand, medium greenish-brown; 60 percent fine angular to subangular clear quartz sand, 25 percent fine-grained dark to light-brown phosphate, 15 percent fine-grained light-gray to light-brown phosphate with lime coating. Trace of coarse-grained dark-brown phosphate, medium subangular clear to frosted quartz sand, light-gray clay. Radiolaria, Foraminifera and diatoms rare, no Ostracoda.
161′5″-164′5″	13.8	Phosphatic sand, medium greenish-brown; same as 159′1″-161′5″ interval.
164′5″-167′5″	12.6	Phosphatic sand, medium greenish-brown; same as 161′5″-164′5″ interval with 10 percent increase in light-gray clay and corresponding decrease in fine quartz sand. Radiolaria, diatoms, sponge spicules, and Foraminifera rare, no Ostracoda.
167′5″-169′0″	10.4	Phosphatic sand, medium greenish-brown; same as 164′5″-167′5″ interval.
169′0″-173′1″	11.9	Phosphatic sand, medium greenish-brown; 50 percent very fine to fine angular to subangular clear quartz sand, 20 percent very fine to fine-grained dark-brown to black phosphate, 15 percent coarse-sand to medium-gravel-size particles of dark-brown to black phosphate, 15 percent light-gray clay. Trace of medium angular to subangular clear quartz sand, rose quartz, fine to medium white broken shell fragments. Foraminifera, diatoms, and radiolaria rare, no Ostracoda.
173′1″-175′8″	5.99	Phosphatic sand, medium greenish-brown; 65 percent very fine angular to subangular clear quartz sand, 20 percent very fine to fine-grained dark-brown to black phosphate, 15 percent light-gray calcareous clay. Trace of coarse-grained dark-gray to black phosphate, medium subangular to subrounded clear quartz sand, very fine-grained light-green glauconite. Diatoms very rare, no Foraminifera, radiolaria, or Ostracoda.
175′8″-179′6″	4.17	Sand, medium greenish-gray; same as 173′1″-175′8″ interval with 10 percent increase in very fine quartz sand and corresponding decrease in phosphate. Trace of coarse-sand to fine-gravel-size aggregates of white limestone and glauconite. Foraminifera, diatoms, and sponge spicules rare, no Ostracoda.
179′6″-182′3″	4.58	Sandy limestone, light greenish-gray; 50 percent light-gray microcrystalline well indurated limestone matrix, 35 percent very fine to fine angular to subangular clear quartz sand, 15 percent very fine to fine-grained dark-brown to black phosphate. Coarse-grained dark-brown to black phosphate, medium to coarse subangular to rounded clear to frosted quartz sand, very fine-grained bright-green glauconite prominent. Trace of smoky quartz. Diatoms very rare, no Foraminifera, sponge spicules or Ostracoda.
182′3″-185′7″	9.33	Phosphatic sand and calcareous clay, medium greenish-brown to medium olive-green. The interval 182′3″-183′9″ consists of medium greenish-brown phosphatic sand, composition as follows: 45 percent fine subangular to subrounded clear quartz sand, 35 percent fine to medium-grained dark-brown to black phosphate, 15 percent medium-gray calcareous clay, 5 percent coarse-sand to fine-gravel-size particles of dark -brown to black phosphate. The interval 183′9″-184′9″ consists of medium olive-green clay, composition as follows: 85 percent medium olive-green highly calcareous clay, 15 percent fine angular to subangular clear quartz sand. Trace of fine-grained dark-brown to black phosphate. The interval 184′9″-185′7″ is composed of phosphatic sand, same as 182′3″-183′9″ interval. For entire interval:

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		Foraminifera and sponge spicules common, no diatoms or Ostracoda.
185′7″-186′1″	6.76	Clay and phosphatic sand, medium olive-green; this interval consists chiefly of medium olive-green calcareous clay with scattered thin layers of phosphatic sand. For entire interval: 55 percent medium olive-green highly calcareous clay, 25 percent very fine to fine angular to subangular clear quartz sand, 15 percent very fine to fine-grained dark-brown to black phosphate, 5 percent coarse-sand to medium-gravel-size particles of dark-brown to black phosphate. Trace of coarse subrounded clear to frosted quartz sand, fine to very coarse white broken shell fragments. Foraminifera abundant, sponge spicules rare, no Ostracoda.
186′1″-186′9″	7.61	Sand and clay, light-gray; 40 percent very fine angular clear quartz sand, 25 percent medium subangular to subrounded clear to frosted quartz sand, 25 percent white highly calcareous clay, 10 percent fine to medium white broken shell fragments. Coarse-grained dark-brown to black phosphate prominent. Trace of smoky quartz. Foraminifera and sponge spicules rare, no Ostracoda.
189′5″-190′11″	3.07	Phosphatic limestone, medium greenish-gray, well indurated; 70 percent light-gray very fine crystalline well indurated limestone matrix, 20 percent very fine-grained dark-brown to black phosphate, 10 percent fine angular clear quartz sand. Trace of coarse-grained dark-gray to black phosphate. Foraminifera rare, no sponge spicules or Ostracoda.
190′11″-192′5″	7.26	Phosphatic clay and sand, medium greenish-gray; 55 percent medium-gray calcareous clay, 20 percent very fine-grained light-brown to black phosphate, 20 percent very fine angular to subangular clear quartz sand, 5 percent coarse-sand to medium-gravel-size particles of white to light-gray limestone and phosphate. Trace of coarse-grained light-brown phosphate, fine-grained bright-green glauconite. Foraminifera very abundant, no Ostracoda.
192′5″-196′11″	7.85	Clay, dark olive-green; 80 percent dark olive-green calcareous clay, 10 percent very fine-grained light to dark-brown phosphate, 10 percent very fine angular clear quartz sand. Trace of medium to coarse-grained light-brown to black phosphate, medium subangular to subrounded clear quartz sand, fine white broken shell fragments, smoky quartz, amber. Foraminifera abundant, no Ostracoda.
196′11″-199′6″	4.50	Clay, dark olive-green; same as 192′5″-196′11″ interval with Foraminifera very abundant, no Ostracoda.
199′6″-204′3″		No sample.
204′3″-204′11″	8.79	Phosphatic sandy limestone, medium greenish-gray; 45 percent light-gray microcrystalline will indurated limestone matrix, 30 percent very fine to fine angular to subangular clear quartz sand, 25 percent very fine to fine-grained dark-brown to black phosphate. Trace of coarse-grained dark-gray to black phosphate, medium subangular clear quartz sand. Foraminifera very rare, no Ostracoda.
204′11″-206′3″	12.8	Phosphatic sand, dark greenish-brown; 55 percent very fine to fine angular to subangular clear quartz sand, 45 percent very fine to fine-grained dark-brown to black phosphate. Light-gray clay prominent. Trace of coarse-grained dark-gray to black phosphate, medium to coarse subrounded clear to frosted quartz sand, medium white broken shell fragments. Foraminifera rare, no Ostracoda.
206′3″-209′10″	8.02	Phosphatic sand, dark greenish-brown; same as 204′11″-206′3″ interval with no microfossils.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
209′10″-211′0″	4.02	Phosphatic sandy limestone, light-gray to white; 55 percent white to light-gray microcrystalline poorly indurated limestone matrix, 25 percent medium to coarse-grained dark-gray to black phosphate, 20 percent medium subangular to subrounded clear quartz sand. Trace of fine to medium-gravel-size particles of dark-gray to black phosphate, coarse subrounded clear quartz sand, fine to medium white broken shell fragments. Foraminifera very rare, no Ostracoda.

Belhaven quadrangle BE-2-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
194′3″-195′3″	2.74	Sand and clay, medium greenish-gray; 55 percent fine angular to subangular clear quartz sand, 25 percent light greenish-gray clay, 10 percent fine-grained dark-brown to black phosphate, 10 percent medium subangular to subrounded clear quartz sand. Trace of coarse-sand-size particles of dark-brown to black phosphate, very fine-grained light-green glauconite, smoky quartz, rose quartz. Foraminifera rare, no Ostracoda.
195′3″-196′3″	2.74	Sand and clay, medium greenish-gray; same as 194′3″-195′3″ interval with Foraminifera and diatoms rare, no Ostracoda.
196′3″-197′3″	4.24	Sand and clay, medium greenish-gray; same as 195′3″-196′3″ interval with Foraminifera rare, no diatoms or Ostracoda.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
197′3″-198′3″	4.24	Sand and clay, medium greenish-gray; 50 percent medium subangular to subrounded clear quartz sand, 25 percent light greenish-gray clay, 15 percent fine angular to subangular clear quartz sand, 10 percent fine-grained dark-brown to black phosphate. Trace of medium rounded clear quartz sand, coarse subrounded clear quartz sand, very fine-grained light-green glauconite. Foraminifera rare, no Ostracoda.
198′3″-199′2″	4.24	Sand and clay, medium greenish-gray; same as 197′3″-198′3″ interval with no microfossils.
199′2″-199′6″		No sample.
199′6″-200′6″	4.65	Sand and clay, medium greenish-gray; same as 199′2″-199′6″ interval with Foraminifera rare, no Ostracoda.
200′6″-201′6″	4.65	Sand and clay, medium greenish-gray; same as 199′6″-200′6″ interval with no glauconite. Foraminifera rare, no Ostracoda.
201′6″-202′9″	5.12	Sand and clay, medium greenish-gray; same as 200′6″-201′6″ interval.
202′9″-203′9″	5.12	Sand and clay, dark greenish-brown; 40 percent fine angular to subangular clear quartz sand, 30 percent medium angular to subangular clear quartz sand, 20 percent medium greenish-gray clay, 10 percent fine-grained light-brown to black phosphate. Trace of medium rounded clear quartz sand. No microfossils.
203′9″-204′4″	5.12	Sand and clay, dark greenish-brown; same as 202′9″-203′9″ interval.
204′4″-205′4″	4.97	Sand and clay, medium greenish-brown; alternating layers of dark greenish-brown sand and clay with light greenish-gray sand and clay. The lighter colored layers contain 10 percent to 15 percent more clay than the dark-colored layers. For entire interval: 60 percent fine angular to subangular clear quartz sand, 30 percent dark to light-green clay, 10 percent fine-grained light-brown to black phosphate. Trace of medium subangular to subrounded clear quartz sand, medium-grained dark-brown to black phosphate, amber, very fine-grained light-green glauconite. No microfossils.
205′4″-206′8″	4.97	Sand and clay, medium greenish-brown; same as 204′4″-205′4″ interval.
206′8″-207′10″	4.62	Sand and clay, medium greenish-gray; 60 percent fine angular to subangular clear quartz sand, 20 percent light-greenish-gray clay, 10 percent fine to medium-grained dark-brown to black phosphate, 10 percent coarse subangular clear quartz sand. Trace of rose quartz, medium-gray limestone. The interval 206′8″-207′0″ contains a prominent intercalation of light-gray to white sandy calcareous clay, unconsolidated; composition as follows: 55 percent light-gray to white highly calcareous clay, 35 percent fine subangular to subrounded clear quartz sand, 10 percent fine-grained dark-brown to black phosphate. For entire interval: Foraminifera common, Ostracoda rare.
207′10″-209′0″	4.62	Sand and clay, medium greenish-gray, same as 206′8″-207′10″ interval with 5 percent increase in phosphate and corresponding decrease in fine quartz sand. Trace of very fine-grained light-green glauconite. No microfossils.
209′0″-210′5″	4.62	Sand and clay, medium greenish-gray; same as 207′10″-209′0″ interval.
210′5″-211′5″	5.00	Sand and clay, medium greenish-gray; same as 209′0″-210′5″ interval.
211′5″-212′5″	5.00	Sand and clay, medium greenish-gray; 40 percent fine to very fine angular to subangular clear quartz sand, 30 percent light greenish-gray clay, 15 percent medium subangular to subrounded clear quartz sand, 15 percent fine to medium dark-brown to black phosphate. Medium subrounded frosted quartz sand prominent. Trace of medium-grained dark-brown phosphate, rose quartz, very fine-grained light-green glauconite, lignitized wood. Foraminifera very rare, no Ostracoda.
212′5″-213′5″	5.00	Sand and clay, medium greenish-gray; same as 211′5″-212′5″ interval with 5 percent increase in medium clear quartz sand and corresponding decrease in fine quartz sand. No microfossils.
213′5″-214′3″	5.00	Sand and clay, medium greenish-gray; same as 212′5″-213′5″ interval with Foraminifera very rare, no Ostracoda.
214′3″-215′3″	4.22	Fine sand, dark greenish-brown; 75 percent very fine angular to subangular clear quartz sand, 15 percent very fine to fine-grained light-brown to black phosphate, 10 percent medium subangular to subrounded clear quartz sand. Trace of medium subangular frosted quartz sand, medium-grained light-brown to black phosphate, very fine-grained light-green glauconite. Foraminifera very rare, no Ostracoda.
215′3″-216′6″	4.22	Fine sand, dark greenish-brown; same as 214′3″-215′3″ interval with 5 percent increase in medium quartz sand and corresponding decrease in very fine quartz sand. No glauconite, no microfossils.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
216′6″-217′6″	4.22	Fine sand, dark greenish-brown; same as 215′3″-216′6″ interval.
217′6″-218′6″	4.22	Fine sand, dark greenish-brown; same as 216′6″-217′6″ interval with 5 percent increase in very fine quartz sand and corresponding decrease in medium quartz sand. No microfossils.
218′6″-219′6″	3.37	Fine sand, dark greenish-brown; same as 217′6″-218′6″ interval.
219′6″-221′0″	3.37	Fine sand, dark greenish-brown; same as 218′6″-219′6″ interval with Foraminifera rare, no Ostracoda.
221′0″-222′0″	2.57	Fine sand, dark greenish-brown; same as 219′6″-221′0″ interval with Foraminifera common, no Ostracoda.
222′0″-223′0″	2.57	Fine sand, dark greenish-brown; same as 221′0″-222′0″ interval.
223′0″-224′0″	1.54	Clay and fine sand, medium greenish-brown; 60 percent light greenish-gray clay, 25 percent very fine angular to subangular clear quartz sand, 10 percent fine to medium subangular to subrounded clear to frosted quartz sand, 5 percent fine to medium-grained dark-brown to black phosphate. Foraminifera common, no Ostracoda.
		Middle Miocene—Pungo River Formation
224′0″-224′8″	1.54	Clay, dark olive-green; dark olive-green slightly calacareous clay. Trace of fine-grained angular to subangular clear quartz sand, fine-grained dark-brown to black phosphate. Black clay prominent. This interval contains thin layers of light greenish-gray fine sand. Foraminifera abundant, no Ostracoda.
224′8″-225′7″	1.54	Clay, dark olive-green; same as 224′0″-224′8″ interval with no sand layers. Foraminifera common, no Ostracoda.
225′7″-226′7″	0.76	Clay, dark olive-green; same as 224′8″-225′7″ interval with Foraminifera rare, no Ostracoda.
226′7″-227′7″	0.76	Clay, dark olive-green; dark olive-green calcareous clay. Trace of fine subangular to subrounded clear quartz sand. Foraminifera common, no Ostracoda.
227′7″-228′4″	0.76	Clay, dark olive-green; same as 226′7″-227′7″ interval with Foraminifera very abundant, no Ostracoda.
228′4″-229′4″	0.43	Clay, light olive-green; light olive-green, light-weight slightly calcareous clay. Trace of fine subangular to subrounded clear quartz sand. Foraminifera abundant, no Ostracoda.
229′4″-230′4″	0.43	Clay, light olive-green; same as 228′4″-229′4″ interval with 10 percent of sample composed of diatoms. Foraminifera abundant, no Ostracoda.
230′4″-231′5″	0.43	Clay, light olive-green; 90 percent light olive-green light-weight slightly calcareous clay, 10 percent fine angular to subangular clear quartz sand. Foraminifera very abundant, diatoms rare.
231′5″-232′0″	5.22	Clay, light olive-green; 75 percent light olive-green light-weight slightly calcareous clay, 20 percent fine subangular to angular clear quartz sand, 5 percent fine-grained dark-brown to black phosphate. Foraminifera very abundant, diatoms common.
232′0″-233′0″	5.22	Phosphatic sandy clay, dark olive-green; 50 percent highly calcareous dark olive-green clay, 30 percent fine to medium-grained light-brown to black phosphate, 20 percent fine angular to subangular clear quartz sand. Trace of medium-grained dark-brown to black phosphate. The upper 6 inches of this interval contains spots and layers of light olive-green clay, same as 231′5″-232′0″ interval. Foraminifera common, no diatoms or Ostracoda.
233′0″-233′10″	5.22	Diatomaceous clay, light olive-green; 85 percent light olive-green light-weight slightly calcareous clay, 15 percent of sample composed of diatoms, most arranged in definite layers. Foraminifera common, no Ostracoda.
233′10″-234′5″	5.22	Diatomaceous clay, light olive-green; same as 233′0″-233′10″ interval with trace of fine subrounded clear quartz sand, fine-grained dark-brown to black phosphate. Foraminifera abundant, no Ostracoda.
234′5″-236′5″	14.5	Phosphatic sand and clay, dark greenish-brown; 45 percent fine to medium-grained light-brown to black phosphate, 35 percent fine to medium subangular to subrounded clear quartz sand, 20 percent dark greenish-gray clay. Trace of coarse subrounded clear to frosted quartz sand, coarse-grained dark-brown to black phosphate. Foraminifera abundant, no diatoms or Ostracoda.
236′5″-237′5″	16.6	Phosphatic sand and clay, dark greenish-brown; same as 234′5″-236′5″ interval.
237′5″-238′5″	16.6	Phosphatic sand and clay, dark greenish-brown; same as 236′5″-237′5″ interval with Foraminifera rare, no Ostracoda.
238′5″-239′4″	16.6	Phosphatic sand and clay, dark greenish-brown; same as 237′5″-238′5″ interval with no microfossils.
239′4″-240′4″	18.5	Phosphatic sand and clay, dark greenish-brown; same as 238′5″-239′4″ interval.
240′4″-241′4″	18.5	Phosphatic sand and clay, dark green-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		ish-brown; same as 239′4″-240′4″ interval with 5 percent increase in fine to medium quartz sand and corresponding decrease in phosphate. No microfossils.
241′4″-242′4″	18.5	Phosphatic sand and clay, dark greenish-brown; same as 240′4″-241′4″ interval with trace of lignitized wood, amber. No microfossils.
242′4″-243′0″	19.8	Phosphatic sand, dark greenish-brown; 55 percent fine to medium angular to subangular clear quartz sand, 45 percent fine-grained light-brown to black phosphate. Light-gray weathered phosphate prominent. Trace of coarse-grained dark-brown to black phosphate, medium subrounded clear quartz sand, light to dark-gray fragments of limestone. Foraminifera very rare, no Ostracoda.
243′0″-244′0″	19.8	Phosphatic sand, dark greenish-brown; same as 242′4″-243′0″ interval with 10 percent increase in phosphate and corresponding decrease in fine to medium quartz sand. Foraminifera rare, no Ostracoda.
244′0″-245′8″	19.8	Phosphatic sand, dark greenish-brown; 45 percent fine to medium-grained light-brown to black phosphate, 35 percent medium angular to subangular clear quartz sand, 20 percent fine angular to subangular clear quartz sand. Light-gray weathered phosphate and light-gray clay prominent. Trace of medium-grained dark-brown to black phosphate. Foraminifera very rare, no Ostracoda.
245′8″-246′8″	4.59	Phosphatic sandy limestone, medium greenish-gray; 65 percent very fine crystalline well indurated medium-gray limestone, 20 percent medium angular to subangular clear quartz sand, 15 percent fine to medium-grained light-brown to black phosphate. Foraminifera rare, no Ostracoda.
246′8″-248′10″	4.52	Phosphatic sandy limestone, medium greenish-gray; same as 245′8″-246′8″ interval with no microfossils.
248′10″-259′7″		No sample.
259′7″-259′10″	7.50	Phosphatic sandy limestone, medium greenish-gray; same as 246′8″-248′10″ interval.
259′10″-260′10″	13.7	Phosphatic sand and clay, light greenish-gray; this interval consists of alternating layers of clay and phosphatic sand. For entire interval: 65 percent very fine to fine angular to subangular clear quartz sand, 15 percent light greenish-gray clay; 15 percent very fine to fine-grained light-brown to black phosphate, 5 percent medium-grained light-brown to black phosphate. Medium subangular to subrounded clear quartz sand prominent. Trace of light-gray limestone particles, very fine-grained light-green glauconite. Foraminifera and sponge spicules very rare, no Ostracoda.
260′10″-262′8″	13.7	Phosphatic sand and clay, light greenish-gray; same as 259′10″-260′10″ interval with Foraminifera very rare, no sponge spicules or Ostracoda.
262′8″-263′8″	10.6	Phosphatic sand and clay, light greenish-gray; same as 260′10″-262′8″ interval with 15 percent increase in light greenish-gray clay and corresponding decrease in fine quartz sand. Diatoms and sponge spicules common, no Foraminifera or Ostracoda.
263′8″-264′8″	10.6	Phosphatic clay and sand, light olive-green; alternating irregular layers of light olive-green clay with layers of phosphatic sand. For entire interval: 55 percent light olive-green clay, 25 percent very fine to fine angular to subangular clear quartz sand, 15 percent very fine to fine-grained light-brown to black phosphate, 5 percent medium-grained light-brown to black phosphate. Trace of medium subrounded to rounded clear quartz sand. Small Foraminifera, diatoms, sponge spicules rare, no Ostracoda.
264′8″-265′8″	10.6	Phosphatic clay and sand, light olive-green; same as 263′8″-264′8″ interval with 5 percent increase in medium quartz sand and corresponding decrease in fine-grained phosphate. Diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
265′8″-266′8″	1.36	Phosphatic sandy clay, light olive-green; 75 percent light olive-green slightly calcareous clay, 15 percent very fine to fine-grained angular to subangular clear quartz sand, 10 percent very fine to fine-grained light-brown to black phosphate. Medium subangular to subrounded clear quartz sand and medium-grained dark-brown to black phosphate prominent. Trace of rose quartz, medium broken shell fragments. The sand and phosphate in this interval occur in thin layers. Diatoms rare, no sponge spicules, Foraminifera or Ostracoda.
266′8″-267′9″	1.36	Phosphatic sandy clay, light olive-green; same as 265′8″-266′8″ interval with diatoms and Foraminifera rare, no Ostracoda.
267′9″-268′9″	1.33	Clay, light olive-green; light olive-green slightly calcareous clay. Trace of medium-grained subrounded clear quartz sand, medium-grained dark-brown to black phosphate. Diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
268′9″-269′9″	1.33	Clay, light olive-green; same as 267′9″-268′9″ interval with trace

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		of small white limestone oolites. Diatoms and sponge spicules common, no Foraminifera or Ostracoda.
269′9″-270′10″	0.58	Clay, light olive-green; same as 268′9″-269′9″ interval with diatoms abundant, sponge spicules common, no Foraminifera or Ostracoda.
270′10″-271′10″	0.58	Clay, light olive-green; same as 269′9″-270′10″ interval.
271′10″-272′10″	12.3	Phosphatic sand and clay, dark greenish-brown; 40 percent very fine angular to subangular clear quartz sand, 25 percent very fine-grained dark-brown to black phosphate, 20 percent dark-gray clay, 10 percent medium subangular to subrounded clear quartz sand, 5 percent medium to coarse-grained dark-brown to black phosphate. Trace of small dolomite rhombohedrons in slide. Sponge spicules and diatoms rare, no Foraminifera or Ostracoda.
272′10″-273′2″	12.3	Coarse phosphatic sand and clay, dark greenish-brown; 30 percent coarse subangular to subrounded clear to frosted quartz sand, 25 percent coarse-sand to fine-gravel-size particles of light-brown to black phosphate, 20 percent dark-gray clay, 15 percent medium subangular to subrounded clear quartz sand, 10 percent fine-grained light-brown to black phosphate. Trace of small dolomite rhombohedrons in slide. Foraminifera rare, no Ostracoda.
273′2″-273′9″	1.70	Phosphatic sandy limestone, light greenish-gray; 50 percent light-gray very fine-grained poorly indurated limestone, 30 percent light olive-green calcareous clay, occurring as "patches" in limestone, 10 percent medium subangular to subrounded clear quartz sand, 10 percent medium-grained dark-brown phosphate. No microfossils.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
273′9″-275′1″	0.11	Limestone, medium-gray; very fine crystalline medium-gray well indurated limestone. No microfossils.

Belhaven quadrangle BE-3-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
201.2-203.9	3.4	Sand, medium greenish-gray; 65 percent very fine angular clear quartz sand, 15 percent very fine to fine-grained dark-brown to black phosphate, 10 percent fine to medium angular to subanuglar clear quartz sand, 10 percent light greenish-gray clay. Foraminifera abundant, no Ostracoda.
203.9-204.9	2.2	Sand, medium greenish-gray; same as 201.2-203.9 foot interval.
204.9-205.9	2.2	Sand, medium greenish-gray; same as 203.9-204.9 foot interval with 5 percent decrease in fine to medium quartz sand and corresponding increase in very fine quartz sand. Foraminifera very abundant, no Ostracoda.
205.9-206.9	2.2	Sand and clay, dark greenish-gray; 60 percent very fine angular clear quartz sand, 30 percent medium greenish-brown clay, 10 percent very fine to fine-grained dark-brown to black phosphate. Trace of fine subangular clear quartz sand. Foraminifera very rare, no Ostracoda.
206.9-208.0	3.2	Sand and clay, dark greenish-gray; same as 205.9-206.9 foot interval with Foraminifera common, no Ostracoda.
208.0-210.0	3.2	Sand and clay, dark greenish-gray; this interval consists of dark olive-green clay interbedded with layers of sand and clay. For entire interval: 45 percent very fine angular clear quartz sand, 40 percent dark olive-green clay, 10 percent very fine to fine-grained dark-brown to black phosphate, 5 percent fine subangular to subrounded clear to frosted quartz sand. Trace of limonite-stained quartz sand. Foraminifera abundant, no Ostracoda.
210.0-215.7		No sample.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
215.7-218.4	0.6	Diatomaceous clay, light olive-green; 70 percent light olive-green lightweight slightly calcareous clay, 30 percent diatoms. Trace of fine subangular to subrounded clear quartz sand. This interval contains scattered lenses of white calcareous clay and dark olive-green clay. Foraminifera abundant, no Ostracoda.
218.4-220.0	0.4	Diatomaceous clay, light olive-green; same as 215.7-218.4 foot interval.
220.0-221.3	0.4	Diatomaceous clay, light olive-green; same as 218.4-220.8 foot interval.
221.3-222.0	1.0	Diatomaceous clay, light olive-green; same as 220.0-221.3 foot interval.
222.0-223.0	1.0	Diatomaceous clay and phosphatic sand, light olive-green; this interval consists of diatomaceous clay with thin interbedded lenses of phosphatic sand. For entire interval: 40 percent light-green lightweight diatomaceous clay, same as 221.3-222.0 foot interval, 40 percent fine to medium-grained dark-brown to black phosphate, 20 percent fine angular to subangular clear quartz sand. Foraminifera abundant, no Ostracoda.
223.0-224.5	1.0	Clay, dark olive-green; 90 percent dark olive-green clay, 10 percent fine subangular to subrounded clear quartz sand. Foraminifera common, no diatoms or Ostracoda.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
224.5-225.5	18.3	Phosphatic sand, dark greenish-brown; 65 percent fine to medium-grained light-brown to black phosphate, 35 percent fine to medium angular to subangular clear quartz sand. Trace of frosted subangular to subrounded quartz sand. Foraminifera common, no Ostracoda.
225.5-226.5	18.3	Phosphatic sand, dark greenish-brown; same as 224.5-225.5 foot interval with trace of coarse-sand to fine-gravel-size dark-brown to black phosphate. Foraminifera very rare, no Ostracoda.
226.5-227.0	19.0	Phosphatic sand, dark greenish-brown; same as 225.5-226.5 interval.
227.0-228.0	19.0	Phosphatic sand, dark greenish-brown; same as 226.5-227.0 foot interval.
228.0-229.0	19.1	Phosphatic sand, dark greenish-brown; same as 227.0-228.0 foot interval with no microfossils.
229.0-230.0	19.1	Phosphatic sand, dark greenish-brown; same as 228.0-229.0 foot interval.
230.0-231.0	19.1	Phosphatic sand, dark greenish-brown; same as 229.0-230.0 foot interval with Foraminifera very rare, no Ostracoda.
231.0-232.0		No sample.
232.0-237.0	5.8	Phosphatic sandy limestone, light-gray, well indurated; 35 percent light to medium-gray fine crystalline limestone, 35 percent fine to medium subangular to subrounded clear to frosted quartz sand, 30 percent fine-grained dark-brown to black phosphate. Foraminifera very rare, no Ostracoda. Field log indicates that this interval consists of alternating layers of phosphatic sandy limestone and phosphatic sand and clay.
237.0-247.0	5.8	Phosphatic sandy limestone, light-gray; same as 232.0-237.0 foot interval with limestone lighter in color. Foraminifera, diatoms and sponge spicules rare, no Ostracoda. Field log indicates that this interval consists of alternating layers of phosphatic sandy limestones with phosphatic sand and clay.
247.0-254.0		No sample.
254.0-256.0	5.8	Phosphatic clay and sand, medium greenish-gray; 40 percent medium greenish-gray clay, 30 percent fine subangular to subrounded clear quartz sand, 30 percent fine-grained light to dark-brown phosphate. Trace of fine subrounded frosted quartz sand, medium-sand-size particles of light-gray limestone aggregates. Calcareous clay prominent. Foraminifera and diatoms common, no sponge spicules or Ostracoda.
256.0-257.0	5.8	Sand, medium greenish-gray; 85 percent fine angular to subangular clear quartz sand, 15 percent fine-grained light to dark-brown phosphate. Trace of coarse-grained dark-brown to black phosphate, medium subangular to subrounded clear to frosted quartz sand. Foraminifera rare, no diatoms or Ostracoda.
257.0-258.0	5.8	Sand, medium greenish-gray; same as 256.0-257.0 foot interval.
258.0-259.0	6.2	Sand, medium greenish-gray; same as 257.0-258.0 foot interval with sponge spicules very rare, no Foraminifera or Ostracoda.
259.0-260.0	6.2	Limestone, medium-gray; medium-gray fine crystalline well-indurated limestone. Very fine-grained dark to light-green glauconite prominent. Trace of coarse-grained light to dark-brown phosphate, medium subangular to subrounded clear quartz sand. Foraminifera very rare, no sponge spicules or Ostracoda.

Belhaven quadrangle BE-6-L

Upper Miocene—Yorktown Formation

172.0-173.0	7.8	Phosphatic sand, dark greenish-brown; 50 percent very fine to fine angular to subangular clear quartz sand, 20 percent fine-grained dark-brown to black phosphate, 15 percent coarse-grained dark-brown to black phosphate, 15 percent coarse-sand to fine-gravel-size subangular to subrounded clear to frosted quartz. Trace of smoky quartz. No microfossils.
173.0-174.0	7.8	Phosphatic sand, dark greenish-brown; same as 172.0-173.0 foot interval.
174.0-175.5	7.8	Phosphatic sand, dark greenish-brown; 75 percent very fine to fine angular to subangular clear quartz sand, 20 percent fine-grained dark-brown to black phosphate, 5 percent medium to coarse, subangular to subrounded clear to frosted quartz sand. Coarse-grained dark-brown to black phosphate prominent. No microfossils.
175.5-177.0	5.4	Phosphatic sand, dark greenish-brown; same as 174.0-175.5 foot interval with decrease in medium to coarse quartz sand to only a trace. Corresponding increases in very fine quartz sand. Foraminifera rare, no Ostracoda.
177.0-179.0	5.4	Phosphatic sand, dark greenish-brown; same as 175.5-177.0 foot interval.
179.0-180.0	3.6	Phosphatic sand, dark greenish-brown; same as 177.0-179.0 foot interval.
180.0-182.0	3.6	Sand and clay, dark greenish-brown;

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		45 percent very fine, angular to subangular, clear quartz sand, 40 percent medium greenish-gray slightly calcareous clay, 15 percent very fine to fine-grained dark-brown to black phosphate. Trace of coarse-grained black phosphate, coarse subangular to subrounded clear to frosted quartz sand, smoky quartz, rose quartz. Foraminifera very rare, no Ostracoda.
182.0-183.0	1.7	Sand and clay, dark greenish-brown; same as 180.0-182.0 foot interval with trace of black clay. Foraminifera very rare, no Ostracoda.
183.0-184.0	1.7	Sand and clay, dark greenish-brown; same as 182.0-183.0 foot interval.
184.0-185.0	1.7	Sand and clay, dark greenish-brown; same as 183.0-184.0 foot interval with no black clay. Foraminifera very rare, no Ostracoda.
185.0-186.0	0.8	Clay and sand, dark olive-green; 80 percent medium to dark olive-green clay, 10 percent very fine to fine angular to subangular clear quartz sand, 5 percent very fine to fine-grained dark-brown to black phosphate, 5 percent fine to medium-grained light-brown to light-gray weathered phosphate. Trace of smoky quartz. Foraminifera very rare, no Ostracoda. This interval contains scattered thin layers of white slightly calcareous clay.
186.0-188.0	0.8	Clay and sand, dark olive-green; same as 185.0-186.0 foot interval with decrease in weathered phosphate to only a trace. Corresponding increase in very fine quartz sand. Foraminifera rare, no Ostracoda.
188.0-189.0	0.8	Clay and sand, dark olive-green; same as 186.0-188.0 foot interval.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
189.0-190.0	0.9	Diatomaceous clay, medium olive-green; 70 percent light olive-green light-weight calcareous clay, 15 percent diatoms, 10 percent very fine to fine-grained light-brown to black phosphate, 5 percent fine angular to subangular clear quartz sand. Trace of coarse frosted subrounded quartz sand. Foraminifera abundant, no Ostracoda.
190.0-192.0	0.9	Clay, dark olive-green; dark olive-green slightly calcareous clay. Trace of fine angular to subangular clear quartz sand. Foraminifera common, no diatoms or Ostracoda.
192.0-208.0		No sample.
208.0-213.0	7.8	Phosphatic sandy limestone, medium greenish-gray, well indurated; 40 percent medium-gray fine crystalline limestone, 35 percent fine-grained dark-brown to black phosphate, 25 percent fine subangular to subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.
213.0-221.0		No sample.
221.0-222.5	11.6	Phosphatic sand, medium greenish-gray; 60 percent very fine to fine angular to subangular clear quartz sand, 30 percent fine-grained light to dark-brown phosphate, 10 percent greenish-gray clay. Trace of coarse subangular to subrounded clear to frosted quartz sand, medium-grained light to dark-brown phosphate. Foraminifera rare, no Ostracoda.
222.5-224.0	10.4	Phosphatic sand, medium greenish-gray; same as 221.0-222.5 interval with 10 percent increase in fine-grained phosphate and corresponding decrease in very fine quartz sand. Foraminifera and diatoms very rare, no Ostracoda.
224.0-226.0	10.4	Phosphatic sand, medium greenish-gray; same as 222.5-224.0 foot interval with no microfossils.
226.0-227.0	6.1	Phosphatic sand and diatomaceous clay, light olive-green; this interval consists of interbedded phosphatic sand (same as 224.0-226.0 foot interval) and light olive-green, light-weight diatomaceous clay. For entire interval: 55 percent light olive-green, light-weight calcareous clay, 20 percent very fine to fine angular to subangular clear quartz sand, 15 percent diatoms, 10 percent very fine to fine-grained light-brown to black phosphate. Trace of coarse-grained light-brown phosphate. Sponge spicules rare, no Foraminifera or Ostracoda.
227.0-228.0	9.6	Phosphatic sand, medium greenish-gray; 60 percent fine angular to subangular clear quartz sand, 40 percent fine-grained dark-brown to black phosphate. Medium subangular to subrounded clear quartz sand and medium-grained dark-brown to black phosphate prominent. Foraminifera very rare, no Ostracoda.
228.0-229.0	12.1	Phosphatic sand, medium greenish-gray; same as 227.0-228.0 foot interval with sponge spicules and diatoms rare, no Foraminifera or Ostracoda.
229.0-231.0	12.1	Phosphatic sand, medium greenish-gray; same as 228.0-229.0 foot interval with Foraminifera rare, no diatoms, sponge spicules or Ostracoda.
231.0-232.0	5.0	Phosphatic clay and sand, light greenish-gray; 60 percent light-gray highly calcareous clay, 20 percent fine subangular to subrounded clear quartz sand, 20 percent fine to medium-grained dark-brown to black phosphate. Coarse-grained dark-brown to black phos-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		phate prominent. Diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
232.0-233.0	5.0	Limestone, light greenish-gray; 85 percent medium-gray fine crystalline limestone, poorly indurated, 10 percent fine subangular to subrounded clear quartz sand, 5 percent fine to medium-grained dark-brown phosphate. Very fine-grained dark to light-green glauconite prominent. Foraminifera very rare, no diatoms, sponge spicules, or Ostracoda.

Belhaven quadrangle BE-8-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
180.9-184.3	5.7	Sand, medium greenish-gray; 70 percent very fine angular to subangular clear quartz sand, 20 percent very fine to medium-grained light-brown to black phosphate, 10 percent medium subangular to subrounded clear quartz sand. Trace of rose quartz, very fine-grained bright-green glauconite. No microfossils.
184.3-187.5	5.3	Sand, medium greenish-gray; same as 180.9-184.3 foot interval with 20 percent increase in medium subangular to subrounded clear quartz sand and corresponding decrease in fine quartz sand. No microfossils.
187.5-189.0	4.0	Sand and clay, medium greenish-gray; 40 percent light-green slightly calcareous clay, 35 percent fine subangular to subrounded clear quartz sand, 15 percent fine-grained dark-brown to black phosphate, 10 percent very fine angular to subangular clear quartz sand. Trace of coarse-grained dark-brown to black phosphate. No microfossils.
189.1-190.5	3.8	Phosphatic sand and clay, medium greenish-gray; 40 percent medium-gray slightly calcareous clay, 30 percent very fine angular to subangular clear quartz sand, 20 percent fine-grained light-brown to black phosphate, 10 percent coarse subangular to subrounded clear quartz sand. Medium-grained dark-brown to black phosphate prominent. No microfossils.
190.5-192.8	4.6	Phosphatic sand, medium greenish-gray; 60 percent very fine angular to subangular clear quartz sand, 20 percent medium subangular to subrounded clear to frosted quartz sand, 20 percent fine to medium-grained light-brown to black phosphate. Trace of rose quartz, very fine-grained bright-green glauconite. No microfossils.
192.8-195.5	6.2	Phosphatic sand, medium greenish-gray; same as 190.5-192.8 foot interval.
195.5-199.0	6.2	Phosphatic sand, medium greenish-gray; same as 192.8-195.5 foot interval with 10 percent decrease in medium quartz sand and corresponding increase in very fine quartz sand. No microfossils.
199.0-200.0	2.9	Sand and clay, medium greenish-brown; 65 percent very fine angular to subangular clear quartz sand, 20 percent light-gray highly calcareous clay, 10 percent fine-grained dark-brown to black phosphate, 5 percent fine subangular to subrounded clear quartz sand. Trace of rose quartz, Foraminifera common, no Ostracoda.
200.0-202.5	2.8	Sand and clay, medium greenish-gray; same as 199.0-200.0 foot interval.
202.5-206.1	2.6	Sand and clay, medium greenish-gray; 55 percent very fine angular to subangular clear quartz sand, 40 percent light-gray calcareous clay, 5 percent very fine-grained dark-brown to black phosphate. Trace of medium subangular to subrounded clear to frosted quartz sand. Foraminifera common, no Ostracoda.
206.1-208.0	2.9	Clay and sand, medium greenish-gray; same as 202.5-206.1 foot interval with 20 percent increase in calcareous clay and corresponding decrease in very fine quartz sand. Foraminifera and sponge spicules very rare, no Ostracoda.
208.0-214.0		No sample.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
214.0-216.5	0.6	Diatomaceous clay, light olive-green; 50 percent light-weight, light olive-green calcareous clay, 40 percent of sample is composed of diatoms, 10 percent fine subangular to subrounded clear quartz sand. Trace of fine-grained dark-brown to black phosphate. Foraminifera rare, no Ostracoda.
216.5-219.4	4.3	Diatomaceous sand and clay, medium olive-green; the upper one foot of this interval is diatomaceous clay, same as 214.0-216.5 foot interval. The lower 1.9 feet consists of phosphatic diatomaceous sand and clay, composition as follows: 30 percent diatoms, 30 percent light-green calcareous clay, 20 percent fine-grained dark-brown to black phosphate, 20 percent very fine to fine subangular to subrounded clear quartz sand. For entire interval: Foraminifera and diatoms abundant, no Ostracoda.
219.4-221.8	13.2	Phosphatic sand, dark greenish-brown; the upper one foot of this interval contains interbedded light-green calcareous clay and phosphatic sand. The lower 1.4 feet is dark greenish-brown phosphatic sand, composition as follows: 55

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		percent fine-grained light-brown to black phosphate, 45 percent very fine to fine angular to subangular clear quartz sand. Trace of medium-grained phosphate, fine subrounded clear quartz sand. Foraminifera and sponge spicules rare, no Ostracoda.
221.8-224.0	17.7	Phosphatic sand, dark greenish-brown; same as 219.4-221.8 foot interval with no calcareous clay. Foraminifera and sponge spicules very rare, no Ostracoda.
224.0-225.0	19.4	Phosphatic sand, dark greenish-brown; same as 221.8-224.0 foot interval with Foraminifera very rare, no sponge spicules or Ostracoda.
225.0-227.0	19.1	Phosphatic sand, dark greenish-brown; same as 224.0-225.0 foot interval.
227.0-228.0	22.2	Phosphatic sand, dark greenish-brown; same as 225.0-227.0 foot interval with phosphoritized diatoms rare, no Foraminifera or Ostracoda.
228.0-229.0	22.2	Phosphatic sand, dark greenish-brown; same as 227.0-228.0 foot interval with Foraminifera and phosphoritized diatoms rare, no Ostracoda.
229.0-230.0	22.2	Phosphatic sand, dark greenish-brown; same as 228.0-229.0 foot interval with no microfossils.
230.0-232.5	8.6	Phosphatic limestone, medium greenish-gray, well indurated; 80 percent medium-gray fine crystalline limestone, 20 percent fine-grained dark-brown to black phosphate. Trace of fine subangular to subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.
232.5-235.5		No sample.
235.5-237.0	3.0	Phosphatic sandy limestone, medium greenish-gray, well indurated; 55 percent medium-gray fine crystalline limestone, 25 percent fine-grained dark-brown to black phosphate, 20 percent fine subangular to subrounded clear quartz sand. No microfossils.
237.0-247.0	2.5	Phosphatic sandy limestone, light greenish-gray; same as 235.5-237.0 foot interval except poorly indurated. No microfossils. Field log indicates that this interval consists of alternating layers of sand and limestone. Limestone only recovery due to drilling with rock barrel.
247.0-250.7		No sample.
250.7-252.0	13.6	Phosphatic sand, dark greenish-brown; 55 percent very fine angular to subangular clear quartz sand, 20 percent very fine to fine-grained light-brown to black phosphate, 15 percent fine angular to subangular clear quartz sand, 10 percent medium-grained light-brown to black phosphate. Trace of hematite-stained quartz, very fine-grained bright-green glauconite. No microfossils.
252.0-254.0	13.6	Phosphatic sand, dark greenish-brown; same as 250.7-252.0 foot interval with 10 percent increase in very fine-grained phosphate and corresponding decrease in fine quartz sand. Trace of lignitized wood. Diatoms very rare, no Foraminifera or Ostracoda.
254.0-255.2		No sample.
255.2-257.1	0.6	Limestone, medium greenish-gray; 80 percent light-gray fine crystalline poorly indurated limestone, 10 percent fine to medium-grained dark-brown phosphate, 10 percent fine-grained subangular to subrounded clear quartz sand. Very fine-grained bright-green glauconite prominent. Foraminifera very rare, no diatoms or Ostracoda.
257.1-258.1	0.9	Calcareous clay, medium olive-green; 80 percent medium olive-green calcareous clay, 10 percent very fine to fine angular to subangular clear quartz sand, 10 percent very fine to fine-grained light-brown to black phosphate. Trace of medium-grained black to dark-brown phosphate, white aggregates of limestone. No microfossils.
258.1-259.4	0.9	Calcareous clay, medium olive-green; same as 257.1-258.1 foot interval with phosphoritized diatoms very rare, no Foraminifera or Ostracoda.
259.4-260.4	2.1	Calcareous clay and sand, medium olive-green; this interval consists chiefly of calcareous clay with scattered interbedded lenses of phosphatic sand. For entire interval: 65 percent medium olive-green calcareous clay, 20 percent very fine to fine angular to subangular clear quartz sand, 15 percent very fine to fine-grained light-brown to black phosphate. Trace of medium-grained dark-brown to black phosphate. Foraminifera very rare, no diatoms or Ostracoda.
260.4-261.4	2.1	Calcareous clay and sand, medium olive-green; same as 259.4-260.4 foot interval with diatoms very rare, no Foraminifera or Ostracoda.
261.4-262.0	2.1	Calcareous clay and sand, medium olive-green; 50 percent calcareous medium olive-green clay, 20 percent very fine to fine angular to subangular clear quartz sand, 15 percent very fine crystalline light-gray poorly indurated limestone, 15 percent very fine to fine-grained light-brown to black phosphate. Trace of medium-grained dark-brown to black phosphate. Diatoms very rare, no Foraminifera or Ostracoda.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
262.0-262.4		No sample.
262.4-263.4	2.1	Limestone, medium greenish-gray; 70 percent very fine crystalline medium greenish-gray poorly indurated limestone, 15 percent fine angular to subangular clear quartz sand, 15 percent very fine-grained dark-brown to black phosphate. Very fine-grained bright-green glauconite prominent. Trace of rose quartz. Phosphoritized diatoms very rare, no Foraminifera or Ostracoda.
263.4-264.4	2.1	Limestone, medium greenish-gray; same as 262.4-263.4 foot interval with coarse-grained black phosphate prominent. No microfossils.
264.4-265.0	2.1	Limestone, medium greenish-gray; same as 263.4-264.4 foot interval except well indurated. No microfossils.
265.0-267.2		No sample.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
267.2-268.0	7.4	Limestone, medium-gray; the upper 0.6 foot of this interval consists of well-indurated medium-gray phosphatic limestone. Composition as follows: 70 percent very fine crystalline medium-gray limestone, 20 percent very fine to medium-grained dark-brown to black phosphate, 10 percent fine-grained angular to subangular clear quartz sand. The lower foot of the interval consists of well indurated shell limestone, composition as follows: very-fine crystalline highly consolidated light to medium-gray limestone. Trace of fine-grained dark-brown to black phosphate, fine subangular to subrounded clear quartz sand. Roughly 60 percent of this lower interval consists of fossil casts and molds, often filled with medium-gray limestone which is the same as the upper 0.6 foot of this interval. For entire interval: Foraminifera very rare, no diatoms or Ostracoda.

Belhaven quadrangle BE-12-GL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
179′8″-180′0″	0.88	Calcareous sandstone, light-gray, well indurated; 55 percent fine angular to subangular clear quartz sand, 40 percent light-gray to white limestone matrix, 5 percent fine-grained dark-brown to black phosphate. Ostracoda common, Foraminifera rare.
180′0″-180′10″	5.18	Sand, medium greenish-gray; 45 percent very fine to fine angular to subangular clear quartz sand, 40 percent medium angular to subangular clear quartz sand, 15 percent fine to medium-grained light-brown to black phosphate. Trace of coarse-sand-size black phosphate, coarse quartz sand, frosted quartz sand. Diatoms and Foraminifera rare, no Ostracoda.
180′10″-181′10″	3.63	Sand and clay, medium greenish-gray; 55 percent very fine to fine angular to subangular clear quartz sand, 25 percent light greenish-gray slightly calcareous clay, 10 percent fine to medium-grained light-brown to black phosphate, 10 percent medium angular to subangular clear quartz sand. Trace of medium frosted quartz sand, medium-sand-size particles of dark-brown to black phosphate, fine-grained light-green glauconite. No microfossils.
181′10″-182′10″	4.29	Sand and clay, medium greenish-gray; same as 180′10″-181′10″ interval with no glauconite. Ostracoda rare, no Foraminifera.
182′10″-183′11″	4.29	Sand and clay, medium greenish-gray; same as 181′10″-182′10″ interval with diatoms rare, no Foraminifera or Ostracoda.
183′11″-184′11″	5.48	Sand and clay, medium greenish-gray; 35 percent fine angular to subangular clear quartz sand, 35 percent light greenish-gray slightly calcareous clay, 15 percent medium to coarse angular to subangular clear quartz sand, 15 percent fine- to coarse-grained light-brown to black phosphate. Trace of medium subrounded frosted quartz gravel, very fine-grained light-green glauconite. Diatoms rare, no Foraminifera or Ostracoda.
184′11″-185′11″	5.48	Sand and clay, medium greenish-gray; same as 183′11″-184′11″ interval with trace of amber. No microfossils.
185′11″-187′4″	5.48	Sand and clay, medium greenish-gray; same as 184′11″-185′11″ interval with no amber. Foraminifera and diatoms rare, no Ostracoda.
187′4″-188′4″	6.68	Sand and clay, medium greenish-gray; same as 185′11″187′4″ interval with 10 percent increase in medium to coarse quartz sand and corresponding decrease in fine quartz sand. Foraminifera and diatoms very rare, no Ostracoda.
188′4″-189′5″	6.68	Sand, medium greenish-brown; 70 percent very fine to fine angular to subangular clear quartz sand, 15 percent very fine to medium-grained light-brown to black phosphate, 10 percent light-gray clay, 5 percent medium subangular to subrounded clear quartz sand. Trace of dark-gray limestone and phosphate aggregates, rose quartz, very fine-grained light-green glauconite. Foraminifera and diatoms rare, no Ostracoda.
189′5″-190′5″	5.96	Sand, medium greenish-brown; same as 188′4″-189′5″ interval.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
190′5″-191′5″	5.96	Phosphatic sand and clay, medium greenish-gray; 50 percent very fine to fine angular to subangular clear quartz sand, 20 percent light-gray highly calcareous clay, 20 percent fine to medium-grained light-brown to black phosphate, 10 percent medium subangular to subrounded clear to frosted quartz sand. Trace of dark-gray limestone and phosphate fragments, medium-grained dark-brown to black phosphate. Foraminifera, diatoms, and sponge spicules rare, no Ostracoda.
191′5″-192′9″	5.96	Phosphatic sand and clay, medium greenish-gray; same as 190′5″-191′5″ interval with coarse subrounded clear quartz sand prominent. Foraminifera abundant, no diatoms, sponge spicules, or Ostracoda.
192′9″-193′9″	4.62	Phosphatic sand and clay, medium greenish-gray; same as 191′5″-192′9″ interval.
193′9″-194′10″	4.62	Sand, medium greenish-gray; 75 percent very fine angular to subangular clear quartz sand, 10 percent light-gray highly calcareous clay, 10 percent very fine to medium-grained dark-brown to black phosphate, 5 percent medium subangular to subrounded clear to smoky quartz sand. Trace of smoky quartz, coarse-sand-size particles of black phosphate. Foraminifera very abundant, no Ostracoda.
194′10″-195′8″	3.58	Sand, medium greenish-gray; same as 193′9″-194′10″ interval.
195′8″-196′3″	3.58	Sand, medium greenish-gray; same as 194′10″-195′8″ interval.
196′3″-197′3″	2.68	Sand, medium greenish-gray; same as 195′8″-196′3″ interval.
197′3″-198′4″	2.68	Sand, medium greenish-gray; same as 196′3″-197′3″ interval.
198′4″-199′4″	2.54	Sand, medium greenish-gray; same as 197′3″-198′4″ interval with slight decrease in phosphate. Trace of light-gray limestone, medium broken shell fragments. Foraminifera common, no Ostracoda.
199′4″-200′6″	2.54	Sand and clay, medium greenish-gray; 65 percent very fine angular to subangular clear quartz sand, 25 percent light greenish-gray slightly calcareous clay, 10 percent very fine-grained dark-brown to black phosphate. Medium subangular to subrounded clear to frosted quartz sand prominent. Trace of medium-grained dark-brown to black phosphate, light-gray limestone fragments. This interval contains a large piece of fossil wood. Foraminifera common, diatoms rare, no Ostracoda.
200′6″-201′6″	2.20	Sand and clay, medium greenish-gray; same as 199′4″-200′6″ interval with no fossil wood. Foraminifera rare, no diatoms or Ostracoda.
201′6″-202′6″	2.20	Clay and sand, medium greenish-gray; 60 percent medium greenish-gray clay, 36 percent very fine angular to subangular clear quartz sand, 5 percent very fine-grained dark-brown to black phosphate. Medium subangular to subrounded clear to frosted quartz sand prominent. Trace of fine to medium-grained dark-brown to black phosphate. Diatoms, Foraminifera, and sponge spicules rare, no Ostracoda.
202′6″-203′10″	2.20	Clay, dark olive-green; 75 percent medium greenish-gray clay, 15 percent very fine angular to subangular clear quartz sand, 10 percent very fine-grained dark-brown to black phosphate. Trace of medium subangular to subrounded clear quartz sand. Diatoms very rare, no other microfossils. The upper 3 inches of this interval is clay and fine sand, same as 201′6″-202′6″ interval. The lower 4 inches contains layers of very dark olive-green clay.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
203′10″-204′8″	1.58	Clay, dark olive-green; black to dark olive-green clay. Trace of medium subrounded clear quartz sand, fine-grained reddish-brown phosphate. Foraminifera and diatoms rare, no Ostracoda.
204′8″-205′3″	1.58	Clay, dark olive-green; 95 percent dark olive-green clay, 5 percent medium-grained reddish-brown phosphate. Trace of medium subrounded clear quartz sand. Foraminifera and diatoms rare, no Ostracoda.
205′3″-212′5″	0.91	Clay, medium olive-green; light-green clay. Trace of fine subangular to subrounded clear quartz sand, fine-grained light-brown to reddish-brown phosphate. Foraminifera and diatoms very abundant, no Ostracoda.
212′5″-218′0″	0.91	Diatomaceous clay, light olive-green; same as 205′3″-212′5″ interval with 10 percent of sample composed of diatoms. Foraminifera common, no Ostracoda.
218′0″-218′8″		No sample.
218′8″-221′0″	15.2	Phosphatic sand, dark greenish-brown; 50 percent fine to medium angular to subrounded clear quartz sand, 50 percent fine to medium light-brown to black phosphate. Trace of coarse subrounded clear quartz sand, coarse-grained dark-brown phosphate, light-tan limestone aggregates. Foraminifera very abundant, no Ostracoda.
221′0″222′0″	17.4	Phosphatic sand, dark greenish-brown; same as 218′8″-221′0″ interval with Foraminifera and diatoms rare, no Ostracoda.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
222′0″-223′0″	17.4	Phosphatic sand, dark greenish-brown; same as 221′0″-222′0″ interval with 10 percent increase in phosphate and corresponding decrease in quartz sand. Foraminifera and diatoms rare, no Ostracoda.
223′0″-223′10″	17.4	Phosphatic sand, dark greenish-brown; same as 220′0″-223′0″ interval with diatoms rare, no Foraminifera or Ostracoda.
223′10″-226′9″	18.1	Phosphatic sand, dark greenish-brown; same as 223′0″-223′10″ interval.
226′9″-229′3″	18.1	Phosphatic sand, dark greenish-brown; same as 223′0″-223′10″ interval.
229′3″-232′2″		No sample.
232′2″-233′10″	5.65	Phosphatic sandy limestone, medium greenish-gray, well indurated; 45 percent medium-gray very fine crystalline limestone matrix, 35 percent fine-grained light to dark-brown phosphate, 20 percent fine subangular to subrounded clear quartz sand. Sponge spicules rare, no Foraminifera, diatoms, or Ostracoda.
233′10″-235′0″		No sample.
235′0″-235′9″	5.65	Phosphatic sandy limestone, medium greenish-gray; same as 232′2″-233′10″ interval with diatoms, Foraminifera, and sponge spicules rare. No Ostracoda.

Bunyan quadrangle BU-10-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
40′0″-42′9″	1.64	Sand and clay, medium-gray; 80 percent fine subangular to subrounded clear quartz sand, 20 percent medium-gray calcareous clay. Fine to medium white broken shell fragments prominent. Trace of fine to medium-grained dark-brown to black phosphate, rose quartz. Foraminifera common, no Ostracoda.
42′9″-44′0″	1.39	Sand and clay, medium-gray; same as 40′0″-42′9″ interval with coarse-sand to medium-gravel-size particles of dark-brown to black phosphate prominent. Foraminifera abundant, Ostracoda rare.
44′0″-45′11″	1.39	Sand and clay, medium-gray; same as 42′9″-44′0″ interval with Foraminifera rare, no Ostracoda.
45′11″-48′10″	2.41	Sand, medium greenish-gray; 80 percent fine subangular to subrounded clear to frosted quartz sand, 15 percent medium greenish-gray calcareous clay, 5 percent very fine to medium-grained dark-brown to black phosphate. Trace of coarse-sand to medium-gravel-size particles of dark-gray to black phosphate. Foraminifera very rare, no Ostracoda.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
48′10″-49′0″	7.60	Phosphatic sand and limestone, dark greenish-brown; 40 percent fine to medium subangular to subrounded clear quartz sand, 30 percent fine to medium-grained dark-brown to black phosphate, 30 percent fine to coarse-sand-size particles of light-gray limestone. Trace of rose quartz, coarse-sand to medium-gravel-size particles of dark-brown to black phosphate. Foraminifera very rare, no Ostracoda.
49′0″-49′9″	9.07	Phosphatic sandy limestone, medium greenish-gray, well indurated; 55 percent light greenish-gray microcrystalline limestone matrix, 25 percent very fine to medium-grained dark-brown phosphate, 20 percent fine to medium-grained subangular to subrounded clear quartz sand. Trace of coarse-grained dark-brown phosphate. Foraminifera very rare, no Ostracoda.
49′9″-50′3″	12.4	Phosphatic sand, dark greenish-brown; 40 percent fine angular to subangular clear quartz sand, 30 percent fine to medium-grained dark-brown to black phosphate, 20 percent fine to medium-gravel-size particles of dark-brown to black phosphate, 10 percent dark olive-green clay. Coarse-sand to medium-gravel-size particles of light-gray limestone prominent. Trace of rose quartz. No microfossils.
50′3″-51′0″	3.51	Phosphatic clay, medium olive-green; 40 percent medium olive-green clay, 20 percent fine-grained light-gray limestone crystals, 20 percent very fine to fine-grained dark-brown phosphate, 10 percent fine subrounded clear quartz sand, 10 percent coarse-sand to medium-gravel-size particles of dark-brown to black phosphate. No microfossils.
51′0″-51′10″	1.32	Phosphatic limestone, medium olive-green, poorly indurated; 70 percent poorly indurated fine crystalline medium olive-green limestone matrix, 20 percent very fine to coarse-grained dark-brown to black phosphate, 10 percent fine subrounded clear quartz sand. No microfossils.
51′10″-53′11″	15.9	Phosphatic sand, dark greenish-brown; 40 percent coarse-sand to fine-gravel-size particles of dark-brown to black phosphate, 20 percent dark olive-green clay, 20 percent fine to very fine-grained dark-brown to black phosphate, 20 percent fine subangular to subrounded clear quartz sand. Trace of rose quartz, coarse subrounded frosted quartz sand. Foraminifera and Ostracoda very rare.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
53′11″-55′6″	4.69	Limestone, medium-gray, well indurated; 90 percent microcrystalline

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		medium to dark-gray limestone matrix, 10 percent fine to medium subangular to subrounded clear quartz sand. Trace of fine to medium-grained dark-brown phosphate, fossil casts and molds replaced by limestone. Foraminifera very rare, no Ostracoda.
55′6″-57′0″	0.27	Limestone, white, poorly indurated; microystalline white poorly indurated limestone. Fine-grained light-green glauconite, fine to medium white broken shell fragments, fine subangular to subrounded clear quartz sand prominent. Trace of rose quartz. Foraminifera very rare, no Ostracoda.
57′0″-60′0″	0.27	Glauconitic limestone, greenish-white, poorly indurated; 65 percent fine to coarse-sand-size particles of soft white limestone and fine to coarse white broken shell fragments, 20 percent fine-grained dark to light-green glauconite, 15 percent fine to medium subangular to subrounded clear quartz sand. Trace of rose quartz, fine to medium-gravel-size aggregates of light-gray limestone. No microfossils.
60′0″-61′6″	0.37	Glauconitic limestone, greenish-white, poorly indurated; same as 57′0″-60′0″ interval with Foraminifera and Ostracoda common.
61′6″-69′6″	0.04	Shell limestone, white, well indurated; 70 percent microcrystalline white to light-gray limestone, 30 percent fossil casts and molds replaced by some limestone. Traces of fine to medium subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.

Pantego quadrangle PA-22-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
129′0″-130′0″	5.51	Sand and clay, medium greenish-gray; 45 percent fine subangular to subrounded clear quartz sand, 20 percent medium subangular to subrounded clear quartz sand, 20 percent light grayish-green clay, 15 percent fine to medium-grained light-brown to black phosphate. Coarse-sand to fine-gravel-size particles of dark-brown to black phosphate, prominent. Foraminifera common, no Ostracoda.
130′0″-131′0″	5.51	Sand and clay, medium greenish-gray; 55 percent fine to very fine angular to subangular clear quartz sand, 30 percent medium greenish-gray clay, 10 percent fine to medium-grained light-brown to black phosphate, 5 percent medium to coarse subangular to subrounded clear quartz sand. Foraminifera very abundant, no Ostracoda.
131′0″132′0″	5.51	Sand and clay, dark greenish-brown; same as 130′0″-131′0″ interval with 15 percent decrease in greenish-gray and corresponding increase in medium quartz sand. Trace of medium subrounded quartz gravel, fine-gravel-size particles of dark-brown to black phosphate. Foraminifera abundant, no Ostracoda.
132′0″133′2″	4.92	Sand, dark greenish-brown; 75 percent very fine to fine angular to subangular clear quartz sand, 15 percent fine-grained light-brown to black phosphate, 10 percent greenish-gray clay. Trace of coarse subangular to subrounded clear quartz sand, coarse-sand-size particles of dark-brown to black phosphate, fine-grained rose quartz, fine-grained apple-green glauconite. Foraminifera rare, no Ostracoda.
133′2″-134′2″	4.92	Sand, dark greenish-brown; same as 132′0″-133′2″ interval.
134′2″-135′2″	4.92	Sand, dark greenish-brown; same as 133′2″-134′2″ interval with trace of black clay. Foraminifera rare, no Ostracoda.
135′2″-136′1″	4.92	Phosphatic sand, dark greenish-brown; same as 134′2″-135′2″ interval with 5 percent increase in coarse-sand-size phosphate and corresponding decrease in fine quartz sand. Foraminifera very rare, no Ostracoda.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
136′1″-137′0″	10.7	Phosphatic sand and clay, dark greenish-brown; this interval consists of alternating layers of phosphatic sand (⅛-¼-inch in thickness) with dark olive-green sand and clay layers (average ½-¾-inch in thickness). For entire interval: 60 percent dark olive-green clay, 25 percent fine to medium-grained light to dark-brown phosphate, 15 percent very fine to medium angular to subangular clear quartz sand. Phosphatic sand layers contain 30 percent clay, 45 percent phosphate, 25 percent quartz sand. Foraminifera very abundant, no Ostracoda.
137′0″-138′0″	10.7	Phosphatic clay and sand, medium greenish-gray; 60 percent medium olive-green clay, 20 percent fine to medium-grained light to dark-brown phosphate, 20 percent fine to medium angular to subangular clear quartz sand. Trace of fine-gravel-size dark-brown to black phosphate, coarse broken shell fragments, medium-grained rose quartz. Foraminifera very abundant, no Ostracoda.
138′0″-139′0″	11.8	Phosphatic clay and sand, medium greenish-gray; same as 137′0″-138′0″ interval with 5 percent increase in fine-grained phosphate and corresponding decrease in fine to

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		medium quartz sand. No shell fragments. Foraminifera very abundant, no Ostracoda.
139′0″-140′-0″	13.5	Phosphatic clay and sand, medium greenish-gray; 50 percent medium greenish-gray clay, 30 percent fine to medium subangular to subrounded clear quartz sand, 20 percent fine-grained light-brown to black phosphate. Trace of fine-gravel-size dark-brown to black phosphate. Foraminifera very abundant, no Ostracoda.
140′0″-140′8″	13.5	Phosphatic clay and sand, medium greenish-gray; same as 139′0″-140′0″ interval with 10 percent increase in fine-grained phosphate and corresponding decrease in fine to medium quartz sand. Foraminifera very abundant, no Ostracoda.
140′8″-141′0″	15.2	Phosphatic clay and sand, medium greenish-gray; same as 140′0″-140′8″ interval.
141′0″-142′0″	15.2	Phosphatic sand and clay, dark greenish-brown; 45 percent fine to medium angular to subangular clear quartz sand, 35 percent fine to medium-grained light-brown to black phosphate, 20 percent light greenish-gray clay. Trace of coarse-sand-size particles of light-brown to black phosphate. Foraminifera common, no Ostracoda.
142′0″-143′0″	15.2	Phosphatic sand, dark greenish-brown; 60 percent very fine to medium angular to subangular clear quartz sand, 40 percent fine to medium-grained light-brown to black phosphate. Trace of coarse sand to fine-gravel-size particles of light-brown to black phosphate, light greenish-gray clay. No microfossils.
143′0″-144′0″	18.2	Phosphatic sand, dark greenish-brown; same as 142′0″-143′0″ interval.
144′0″-145′0″	18.2	Phosphatic sand, dark greenish-brown; 55 percent fine to medium-grained dark-brown to black phosphate, 45 percent medium subangular to subrounded clear quartz sand. Coarse-sand-size particles of dark-brown to black phosphate and coarse subangular to subrounded quartz sand prominent. Trace of black clay. No microfossils.
145′0″-146′0″	18.2	Phosphatic sand, dark greenish-brown; same as 144′0″-145′0″ interval with one thin layer of dark olive-green clay at 145′10″-145′11″. No microfossils.
146′0″-146′10″	19.2	Phosphatic sand, dark greenish-brown; same as 145′0″-146′0″ interval with 15 percent increase in medium quartz sand and corresponding decrease in phosphate. No microfossils.
146′10″-147′0″		No sample.
147′0″-147′7″	6.10	Phosphatic sandy limestone, medium-gray; 65 percent very fine crystalline well indurated medium-gray limestone, 20 percent fine to medium-grained light to dark-brown phosphate, 15 percent fine to medium subangular to subrounded clear quartz sand. The interval 147′0″-147′4″ is phosphatic sand, same as 146′0″-146′10″ interval. A thin layer (½-inch thick) of weathered white limestone separates the phosphatic sand and the consolidated limestone. No microfossils.
147′7″-154′5″	6.10	Phosphatic sandy limestone, medium-gray; same as 147′0″-147′7″ interval with 5 percent increase in phosphate and corresponding decrease in limestone. No phosphatic sand, no weathered limestone. No microfossils.
154′5″-160′2″	3.35	Sandy clay, medium olive-green; 75 percent greenish-gray slightly calcareous clay, 20 percent fine subangular to subrounded clear quartz sand, 5 percent fine to medium-grained dark-brown to black phosphate. Trace of coarse subrounded clear quartz sand, fine-gravel-size particles of light-brown to black phosphate. No microfossils.
160′2″-160′5″		No sample.
160′5″-161′7″	1.49	Clay, dark olive-green; 90 percent dark olive-green slightly calcareous clay, 10 percent very fine to fine subangular to subrounded clear quartz sand. Very fine to fine-grained dark-brown to black phosphate prominent. No microfossils.
161′7″-162′7″	1.49	Phosphatic sand and dark olive-green clay. The upper 6 inches of this interval is dark olive-green clay, same as 160′5″-161′7″ interval. The lower 6 inches is medium greenish-gray sand; 60 percent very fine to fine angular to subangular clear quartz sand, 20 percent medium greenish-brown clay, 10 percent medium to coarse subangular to subrounded clear quartz sand, 10 percent fine-grained light to dark-brown phosphate. No microfossils.
162′7″-163′7″	8.12	Sand, medium greenish-gray; same as sand description in 161′7″-162′7″ interval with 10 percent decrease in clay and corresponding increase in fine quartz sand and phosphate. No microfossils.
163′7″-164′7″	8.12	Sand, medium greenish-gray; same as 162′7″-163′7″ interval.
164′7″-165′5″	8.12	Phosphatic sand, medium greenish-gray; 50 percent very fine angular to subangular clear quartz sand, 20 percent very fine-grained dark-brown to black phosphate, 20 percent fine to medium subangular to subrounded clear quartz sand, 10 percent medium greenish-gray clay. Foraminifera very rare, no Ostracoda.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
165′5″-165′11″		No sample.
165′11″-166′11″	2.86	Phosphatic sand, medium greenish-gray; same as 164′7″-165′5″ interval with 10 percent decrease in phosphate and corresponding increase in fine to medium quartz sand and medium greenish-gray clay. Trace of amber. No microfossils.
166′11″-167′11″	1.45	Calcareous sand, medium greenish-gray; 75 percent very fine highly calcareous sand grains, commonly coated with calcareous material, 20 percent medium subangular to subrounded clear quartz sand, 5 percent very fine to fine-grained dark-brown to black phosphate. Trace of rose quartz, coarse-sand-size particles of dark-gray to black phosphate. No microfossils.
167′11″-168′11″	1.45	Calcareous sand, light greenish-gray; same as 166′11″-167′11″ interval.
168′11″-175′7″		No sample.
175′7″-175′9″	0.40	Limestone, light greenish-gray; very fine crystalline light greenish-gray limestone well indurated. Trace of medium subrounded clear quartz sand, fine to medium-grained light-brown phosphate. No microfossils.
175′9″-181′6″		No sample.
181′6″-181′8″	0.07	Limestone, light greenish-gray; same as 175′7″-175′9″ interval with Foraminifera rare, no Ostracoda.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
181′8″-181′11″	0.07	Shell limestone, light to dark-gray; coarse well consolidated light to dark-gray shell limestone. The upper 2 inches of this interval is dark-gray to black and consists of phosphoritized limestone. Trace of medium subrounded clear quartz sand, fine-grained dark-brown to black phosphate. No microfossils.

Pantego quadrangle PA-24-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
129′0″-133′10″	2.86	Sand, medium greenish-gray; 85 percent fine subangular to subrounded clear quartz sand, 10 percent medium-gray clay, 5 percent fine to medium white broken shell fragments. Fine to medium frosted quartz gravel and fine-gravel-size dark-brown to black phosphate prominent. Trace of fine-grained phosphate, rose quartz. Foraminifera, no Ostracoda.
133′10″-134′6″	5.46	Sand and clay, medium greenish-gray; 55 percent fine subangular to subrounded clear quartz sand, 20 percent medium subangular to subrounded clear quartz sand, 15 percent light greenish-gray clay, 10 percent fine to medium-grained dark-brown to black phosphate. Trace of fine-gravel-size dark-brown to black phosphate. Foraminifera very rare, no Ostracoda.
134′6″-135′6″	5.46	Sand and clay, medium greenish-gray; same as 133′10″-134′6″ interval.
135′6″-136′6″	5.46	Sand and clay, medium greenish-gray; same as 134′6″-135′6″ interval with no microfossils.
136′6″-137′6″	5.46	Sand and clay, medium greenish-gray; same as 135′6″-136′6″ interval.
137′6″-138′4″	5.46	Sand and clay, medium greenish-gray; same as 136′6″-137′6″ interval with 5 percent increase in phosphate and corresponding decrease in fine quartz sand. No microfossils.
138′4″-161′10″		No sample.
161′10″-163′6″	3.36	Sand, dark greenish-brown; 90 percent very fine subangular to subrounded clear quartz sand, 5 percent very fine to fine dark-brown to black phosphate, 5 percent fine subangular to subrounded clear quartz sand. Medium quartz sand and coarse-sand-size particles of dark-brown to black phosphate prominent. No microfossils.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
163′6″-164′6″	6.80	Phosphatic clay, dark greenish-brown; 60 percent medium greenish-gray clay; 25 percent very fine to fine-grained dark-brown to black phosphate, 15 percent medium subangular to subrounded clear quartz sand. Trace of medium-sand-size particles of dark-brown to black phosphate. Black clay prominent. No microfossils.
164′6″-165′6″	14.5	Phosphatic sand and clay, dark greenish-brown; 55 percent fine to medium-grained light-brown to black phosphate, 25 percent medium angular to subangular clear quartz sand, 20 percent medium greenish-gray clay. Trace of coarse-sand-size particles of dark-brown to black phosphate, black clay. No microfossils.
165′6″-166′6″	14.5	Phosphatic sand, dark greenish-brown; 60 percent very fine to medium-grained light-brown to black phosphate, 40 percent fine to medium angular to subangular clear quartz sand. Trace of coarse-sand-size dark-brown phosphate, black clay. No microfossils.
166′6″-167′6″	15.8	Phosphatic sand, dark greenish-brown; same as 165′6″-166′6″ interval.
167′6″-168′6″	15.8	Phosphatic sand, dark greenish-brown; same as 166′6″-167′6″ interval with Foraminifera very rare, no Ostracoda.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
168′6″-169′5″	15.8	Phosphatic sand, dark greenish-brown; same as 167′6″-168′6″ interval with no microfossils.
169′5″-170′5″	15.8	Phosphatic sand, dark greenish-brown; same as 168′6″-169′5″ interval.
170′5″-171′5″	18.7	Phosphatic sand, dark greenish-brown; 65 percent fine to medium light-brown to black phosphate, 25 percent fine subangular clear quartz sand, 10 percent medium subangular to subrounded clear quartz sand. Fine-gravel-size particles of dark-brown to black phosphate. Foraminifera very rare, no Ostracoda.
171′5″-172′5″	18.7	Phosphatic sand, dark greenish-brown; same as 170′5″-171′5″ interval with no microfossils.
172′5″-173′5″	19.9	Phosphatic sand, dark greenish-brown; same as 171′5″-172′5″ interval with trace of light greenish-white clay. No microfossils.
173′5″-174′9″	19.9	Phosphatic sand, dark greenish-brown; same as 172′5″-173′5″ interval with no clay. Foraminifera very rare, no Ostracoda.
174′9″-175′6″	14.3	Phosphatic limestone, medium greenish-gray, well indurated; 70 percent very fine crystalline medium-gray limestone, 20 percent very fine to fine-grained light to dark-brown phosphate, 10 percent medium subangular to subrounded clear quartz sand. No microfossils.
175′6″-188′9″		No sample.
188′9″-192′11″	9.99	Phosphatic sand, medium greenish-gray; 65 percent fine subangular to subrounded clear quartz sand, 15 percent very fine to fine-grained light-brown to black phosphate, 10 percent medium subrounded clear quartz sand, 10 percent dark-gray clay. Fine-gravel-size aggregates of dark-gray limestone and phosphate prominent. Trace of coarse-sand-size dark-brown to black phosphate. No microfossils.
192′11″-193′11″	9.99	Phosphatic sand, medium greenish-gray; same as 188′9″-192′11″ interval with no limestone and phosphate aggregates. No microfossils.
193′11″-194′11″	8.56	Phosphatic sand, medium greenish-gray; same as 192′11″-193′11″ interval with 20 percent increase in phosphate and corresponding decrease in fine quartz sand. No microfossils.
194′11″-196′3″	8.56	Phosphatic sand and clay, medium greenish-gray; 40 percent very fine to fine angular to subangular clear quartz sand, 30 percent light greenish-gray clay, 20 percent very fine-grained light to dark-brown phosphate, 10 percent fine subangular to subrounded clear quartz sand. Coarse-sand-size aggregates of dark-gray limestone and phosphate prominent. Trace of fine-sand-size phospate. No microfossils.
196′3″-205′11″	0.67	Limestone, medium-gray; very fine crystalline well indurated medium-gray limestone. Very fine-grained dark-brown to black phosphate prominent. Trace of fine to medium subangular to subrounded clear quartz sand. No microfossils.
205′11″-210′0″	6.95	Limestone, medium-gray, well indurated; same as 196′3″-205′11″ interval.

Pantego quadrangle PA-31-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
161′3″-162′3″	6.20	Sand, medium greenish-gray; 95 percent fine to medium angular to subangular clear quartz sand, 5 percent fine to medium light-brown to black phosphate. Coarse subangular to rounded clear quartz sand and coarse-sand-size particles of light-brown to black phosphate prominent. Trace of smoky quartz, Foraminifera very rare, no Ostracoda.
162′3″-163′4″	6.20	Sand, medium greenish-gray; same as 161′3″-162′3″ interval.
163′4″-164′4″	6.75	Sand, medium greenish-gray; 80 percent fine angular to subangular clear quartz sand, 10 percent medium to coarse subangular to subrounded clear quartz sand, 10 percent fine to medium-grained light-brown to black phosphate. Trace of fine subrounded frosted quartz gravel, fine-gravel-size particles of dark-brown to black phosphate, rose quartz. Foraminifera rare, no Ostracoda.
164′4″-166′0″	6.75	Sand, medium greenish-gray; same as 163′4″-164′4″ interval.
166′0″-167′0″	5.76	Sand and clay, medium greenish-gray; 45 percent medium angular to subangular clear quartz sand, 25 percent coarse subangular to subrounded clear quartz sand, 15 percent light-gray clay, 15 percent fine to medium-grained light-brown to black phosphate. Trace of coarse frosted quartz sand, coarse-sand-size particles of dark-brown to black phosphate, smoky quartz. Foraminifera and Ostracoda rare.
167′0″-168′0″	5.76	Sand and clay, medium greenish-gray; same as 166′0″-167′0″ interval with Foraminifera rare, no Ostracoda.
168′0″-168′7″	7.17	Sand and clay, medium greenish-gray; same as 167′0″-168′0″ interval.
168′7″-169′7″	7.17	Sand and clay, medium greenish-gray; same as 168′0″-168′7″ interval.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
169′7″-170′7″	7.50	Sand, dark greenish-brown; 55 percent medium angular to subangular clear quartz sand, 20 percent coarse subangular to subrounded clear quartz sand, 15 percent fine to coarse-grained light-brown to black phosphate. Fine subrounded to rounded frosted quartz gravel and fine-gravel-size particles of dark-brown to black phosphate prominent. Foraminifera rare, no Ostracoda.
170′7″-171′7″	7.50	Phosphatic sand, dark greenish-brown; 60 percent fine to very fine angular to subangular clear quartz sand, 20 percent fine to medium-grained light-brown to black phosphate, 10 percent light-gray clay, 10 percent coarse subangular to subrounded clear quartz sand. Coarse frosted quartz sand and coarse-sand-size particles of dark-brown to black phosphate prominent. Trace of rose quartz. Foraminifera common, no Ostracoda.
171′7″-172′0″	6.53	Phosphatic sand and clay, dark greenish-brown; 55 percent very fine to fine angular to subangular clear quartz sand, 20 percent fine-grained light-brown to black phosphate, 20 percent dark greenish-black clay, 5 percent medium subangular to subrounded clear quartz sand. Trace of coarse subrounded frosted quartz sand, medium-grained dark-brown to black phosphate. Foraminifera common, no Ostracoda.
172′0″-173′0″	6.53	Phosphatic sand and clay, dark greenish-brown; same as 171′7″-172′0″ interval with Foraminifera very abundant, no Ostracoda.
173′0″-174′0″	6.53	Phosphatic sand and clay, dark greenish-brown; same as 172′0″-173′0″ interval.
174′0″-174′10″	6.53	Phosphatic sand and clay, dark greenish-brown; same as 173′0″-174′0″ interval.
174′10″-175′10″	5.59	Sand and clay, medium greenish-brown; 50 percent very fine to fine angular to subangular clear quartz sand, 20 percent light greenish-gray clay, 15 percent fine to medium-grained light-brown to black phosphate, 10 percent medium angular to subangular clear quartz sand, 5 percent microfossils. Trace of medium frosted quartz sand, rose quartz. Foraminifera very abundant, no Ostracoda.
175′10″-176′10″	5.59	Sand and clay, dark greenish-brown; 60 percent very fine to fine angular to subangular clear quartz sand, 15 percent fine to medium-grained light-brown to black phosphate, 15 percent dark-gray to black clay, 10 percent medium subangular to subrounded clear to frosted quartz sand. Trace of very fine-grained dark to light- green glauconite. Foraminifera abundant, no Ostracoda.
176′10″-177′11″	5.59	Sand and clay, dark greenish-brown; same as 175′10″-176′10″ interval with 5 percent increase in medium quartz sand and corresponding decrease in fine quartz sand. Foraminifera common, no Ostracoda.
177′11″-178′9″	5.88	Sand and clay, dark greenish-brown; same as 176′10″-177′11″ interval with Foraminifera rare, no Ostracoda.
178′9″-179′9″	5.88	Phosphatic sand and clay, dark greenish-brown; same as 177′11″-178′9″ interval with 5 percent increase in phosphate and corresponding decrease in fine quartz sand. Foraminifera rare, no Ostracoda.
179′9″-181′2″	5.88	Sand and clay, dark greenish-brown; 60 percent very fine angular to subangular clear quartz sand, 20 percent light to dark-gray clay, 10 percent very fine to medium-grained light-brown to black phosphate, 10 percent fine to medium subangular to subrounded clear quartz sand. Foraminifera rare, no Ostracoda.
181′2″-182′2″	4.29	Sand and clay, dark greenish-brown; same as 179′9″-181′2″ interval.
182′2″-183′2″	4.29	Sand and clay, dark greenish-brown; same as 181′2″-182′2″ interval.
183′2″-184′2″	4.29	Fine sand and clay, dark greenish-brown; 75 percent very fine to fine angular to subangular clear quartz sand, 15 percent light to dark-gray clay, 10 percent very fine-grained light-brown to black phosphate. Medium angular to subangular clear quartz sand and medium-grained light-brown to black phosphate prominent. Trace of smoky quartz. Foraminifera rare, no Ostracoda.
184′2″-185′2″	3.28	Fine sand and clay, dark greenish-brown; same as 183′2″-184′2″ interval with Foraminifera very rare, no Ostracoda.
185′2″-186′2″	3.28	Fine sand and clay, dark greenish-brown; same as 184′2″-185′2″ interval.
186′2″-187′2″	3.28	Fine sand and clay, dark greenish-brown; same as 185′2″-186′2″ interval.
187′2″-188′2″	2.90	Fine sand and clay, dark greenish-brown; same as 186′2″-187′2″ interval with no microfossils.
188′2″-189′2″	2.90	Fine sand and clay, dark greenish-brown; same as 187′2″-188′2″ interval.
189′2″-190′5″	2.83	Fine sand and clay, dark greenish-brown; same as 188′2″-189′2″ interval.
190′5″-191′5″	2.83	Fine sand and clay, dark greenish-brown; same as 189′2″-190′5″ interval.
191′5″-192′2″	2.83	Fine sand and clay, dark greenish-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		brown; same as 190′5″-191′5″ interval.
		Middle Miocene—Pungo River Formation
192′2″-193′2″	1.00	Clay, dark olive-green; dark olive-green clay, black clay prominent. Trace of fine angular to subangular clear quartz sand, medium subrounded clear quartz sand, fine to medium dark-brown to black phosphate. Diatoms and Foraminifera rare, no Ostracoda.
193′2″-194′2″	1.00	Clay, dark olive-green; same as 192′2″-193′2″ interval with diatoms common, no Foraminifera or Ostracoda.
194′2″-195′2″	1.00	Clay, medium olive-green; same as 193′2″-194′2″ interval with no black clay. Diatoms and Foraminifera rare, no Ostracoda.
195′2″-196′7″	0.46	Clay, medium olive-green; same as 194′2″-195′2″ interval with diatoms rare, no Foraminifera or Ostracoda.
196′7″-197′7″	0.46	Diatomaceous clay, medium olive-green; 90 percent medium olive-green clay, 10 percent of sample composed of diatoms. Trace of medium subrounded clear quartz sand, medium-grained light-gray to dark-brown phosphate. No Foraminifera or Ostracoda.
197′7″-198′7″	0.46	Diatomaceous clay, light olive-green; 85 percent light olive-green very light-weight clay, 15 percent of sample composed of diatoms. No Foraminifera or Ostracoda.
198′7″-199′7″	0.25	Diatomaceous clay, light olive-green; same as 197′7″-198′7″ interval.
199′7″-200′7″	0.25	Diatomaceous clay, light olive-green; same as 198′7″-199′7″ interval.
200′7″-200′11″	0.25	Diatomaceous clay, light olive-green; same as 199′7″-200′7″ interval with trace of black clay. Foraminifera very rare, no Ostracoda.
200′11″-201′11″	1.23	Diatomaceous clay, medium olive-green; 90 percent medium olive-green clay, 10 percent of sample is composed of diatoms. Black clay, hematite-stained clay, fine to medium-grained reddish-brown phosphate prominent. Trace of fine to medium subrounded clear quartz sand, rose quartz. No Foraminifera or Ostracoda.
201′11″-202′11″	1.23	Clay, medium olive-green; Medium olive-green clay. Black clay, medium subrounded to rounded clear quartz sand, diatoms prominent. Trace of fine to medium-grained light-brown to black phosphate. No Foraminifera or Ostracoda. The upper 2 inches of this interval is light olive-green light-weight diatomaceous clay.
202′11″-203′11″	1.23	Clay, medium olive-green; 65 percent medium olive-green clay, 35 percent black clay. Trace of fine angular to subangular clear quartz sand, medium rounded to subrounded clear quartz sand, medium-grained light-brown to black phosphate. Diatoms abundant, no Foraminifera or Ostracoda.
203′11″-204′11″	0.50	Clay, light olive-green; 90 percent light olive-green light-weight clay, 5 percent fine to medium subangular to rounded clear quartz sand, 5 percent reddish-brown to black medium-grained phosphate. Diatoms abundant, sponge spicules rare, no Foraminifera or Ostracoda.
204′11″-205′11″	0.50	Diatomaceous clay, light olive-green; 85 percent light-weight light olive-green clay, 5 percent black clay, 10 percent of sample is composed of diatoms. Sponge spicules rare, no Foraminifera or Ostracoda.
205′11″-206′6″	19.4	Phosphatic sand and clay, medium olive-green; this interval consists of interbedded layers of medium olive-green clay and phosphatic sand. For entire interval: 55 percent medium olive-green clay, 35 percent very fine to fine-grained light-brown to black phosphate, 10 percent fine to medium-grained subangular to subrounded clear quartz sand. Coarse-sand to fine-gravel-size particles of light-brown to black phosphate prominent. Trace of black clay. Diatoms common, sponge spicules rare, no Foraminifera or Ostracoda.
206′6″-207′6″	19.4	Phosphatic sand, dark greenish-brown; 75 percent fine to medium-grained light-brown to black phosphate, 15 percent medium olive-green clay, 10 percent fine to medium subangular to subrounded clear quartz sand. Light-gray weathered phosphate, fine-gravel-size particles of dark-brown to black phosphate prominent. Diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
207′6″-208′6″	19.4	Phosphatic sand, dark greenish-brown; same as 206′6″-207′6″ interval.
208′6″-209′0″	19.4	Phosphatic sand, dark greenish-brown; same as 207′6″-208′6″ interval with diatoms and sponge spicules common. No Foraminifera or Ostracoda. The lower 1 inch of this interval is light-weight, light olive-green diatomaceous clay.
209′0″-210′4″	0.73	Diatomaceous clay, light olive-green; 90 percent light-weight light olive-green clay, 10 percent of sample is composed of diatoms. The upper 5 inches of this interval contains small spots of phosphatic sand, same as 208′6″-209′0″ interval. Sponge spicules common, no Foraminifera or Ostracoda.
210′4″-211′0″	0.76	Diatomaceous clay, light olive-green;

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		90 percent light-weight light olive-green clay, 10 percent of sample is composed of diatoms. Trace of medium subrounded clear to frosted quartz sand. Sponge spicules common, no Foraminifera or Ostracoda.
211′0″-212′4″	0.76	Diatomaceous clay, light olive-green; same as 210′4″-211′0″ interval with lower 2 inches of the interval containing streaks of phosphatic sand, same as 212′4″-213′4″ interval. Sponge spicules rare, no Foraminifera or Ostracoda.
212′4″-213′4″	18.2	Phosphatic sand and clay, medium greenish-brown; alternating layers of medium olive-green clay and phosphatic sand. For entire interval: 50 percent medium olive-green clay, 20 percent fine to medium angular to subrounded clear quartz sand, 30 percent fine to medium-grained dark-brown to black phosphate. Trace of coarse subangular to subrounded clear quartz sand coarse-grained dark-brown to black phosphate, light-gray weathered phosphate. Diatoms abundant, sponge spicules common, no Foraminifera or Ostracoda.
213′4″-214′8″	18.2	Phosphatic sand and clay, medium greenish-brown; same as 212′4″-213′4″ interval with lower 4 inches of the interval composed of dark greenish-brown phosphatic sand, same as 214′8″-217′0″ interval. Foraminifera, diatoms, and sponge spicules common, no Ostracoda.
214′8″-217′0″	20.3	Phosphatic sand, dark greenish-brown; 40 percent very fine to fine-grained dark-brown to black phosphate, 35 percent fine angular to subangular clear quartz sand, 15 percent medium to coarse-grained light-brown to black phosphate, 10 percent medium to coarse subangular to subrounded clear quartz sand. Trace of medium olive-green clay. Diatoms and sponge spicules rare, no Foraminifera, no Ostracoda.
217′0″-225′9″		No sample.
225′9″-229′1″	6.81	Phosphatic sandy limestone, medium greenish-gray; 65 percent fine crystalline medium gray limestone, 20 percent fine to medium subangular to subrounded clear quartz sand, 15 percent fine-grained light-brown to black phosphate. No microfossils.
229′1″-230′1″	13.0	Phosphatic sand, dark greenish-brown; 40 percent very fine to fine angular to subangular clear quartz sand, 35 percent very fine-grained light-brown to black phosphate, 15 percent medium subangular to subrounded clear quartz sand, 10 percent medium olive-green clay. Trace of coarse subrounded clear quartz sand, medium-grained dark-brown to black phosphate, very fine-grained light-green glauconite. Foraminifera and diatoms very rare, no sponge spicules or Ostracoda.
230′1″-232′2″	13.0	Phosphatic sand, dark greenish-brown; same as 229′1″-230′1″ interval with 10 percent increase in fine-grained phosphate and corresponding decrease in fine quartz sand. Diatoms and Foraminifera very rare, no Ostracoda.
232′2″-233′2″	2.93	Calcareous sand, medium olive-green; 80 percent medium olive-green highly calcareous very fine quartz sand, 10 percent fine to medium subangular to subrounded clear quartz sand, 10 percent very fine to fine-grained light to dark-brown phosphate. About 40 percent of this interval consists of pebble-size particles of semiconsolidated whitish calcareous sand. Trace of tan wood. Ostracoda very rare, no Foraminifera.
233′2″-236′4″	2.93	Calcareous sand, medium olive-green; same as 232′2″-233′2″ interval with no wood. Foraminifera very rare, no Ostracoda.
236′4″-236′10″	0.97	Clay, medium olive-green; medium olive-green slightly calcareous clay. Trace of fine to medium-grained light-brown to black phosphate, fine to medium subangular to subrounded clear quartz sand. Diatoms very rare, no Foraminifera or Ostracoda.
236′10″-237′10″	0.97	Clay, medium olive-green; 90 percent medium olive-green clay, 5 percent very fine angular clear quartz sand, 5 percent very fine to fine light-brown to black phosphate. Trace of coarse subrounded clear quartz sand, medium-grained light to dark-brown phosphate. Diatoms rare, no Foraminifera or Ostracoda.
237′10″-238′10″	0.97	Clay, medium olive-green; same as 236′10″-237′10″ interval.
238′10″-240′0″	0.97	Clay, medium olive-green; same as 237′10″-238′10″ interval with diatoms and Foraminifera rare, no Ostracoda.
240′0″-240′3″	4.06	Fine calcareous sand, medium greenish-gray; very fine highly calcareous sand, consolidated but friable. No microfossils.
240′3″-240′6″	1.57	Clay, medium olive-green; 90 percent medium olive-green clay, 5 percent very fine angular clear quartz sand, 5 percent very fine to fine light-brown to black phosphate. Trace of coarse subrounded clear quartz sand, medium-grained light to dark-brown phosphate. Diatoms and Foraminifera rare, no Ostracoda.
240′6″-242′2″		No sample.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
242′2″-243′0″	4.06	Sandy limestone, dark-gray; 60 percent very fine crystalline dark-gray

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		well indurated limestone, 40 percent fine subangular to subrounded clear quartz sand. Trace of fine-grained dark-brown to black phosphate. Interval contains casts and molds of fossils, filled with fine limestone and sand. No microfossils.
243′0″-251′3″		No sample.
251′3″-251′6″	1.57	Sandy limestone, dark-gray; 60 percent very fine crystalline dark-gray well indurated limestone, 40 percent fine to medium subangular to subrounded clear quartz sand. Fine-grained dark-brown to black phosphate prominent. Sample consists chiefly of casts and molds of fossils, filled with fine-grained limestone and sand. No microfossils.

Pamlico Beach quadrangle PB-2-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
172′0″-173′0″	7.23	Sand, dark greenish-brown; 70 percent very fine to fine angular to subangular clear quartz sand, 15 percent coarse subangular to subrounded clear quartz sand, 15 percent fine to medium-grained light-brown to black phosphate. Trace of coarse-grained light to dark-brown phosphate, rose quartz, medium to coarse frosted quartz sand, very fine-grained light to dark-green glauconite. Foraminifera rare, no Ostracoda.
173′0″-174′0″	7.23	Sand, dark greenish-brown; same as 172′0″-173′0″ interval with diatoms very rare, no Foraminifera or Ostracoda.
174′0″-175′0″	7.23	Sand, dark greenish-brown; same as 173′0″-174′0″ interval with no microfossils.
175′0″-176′0″	4.88	Sand, dark greenish-brown; same as 174′0″-175′0″ interval.
176′0″-177′0″	4.88	Sand, dark greenish-brown; same as 175′0″-176′0″ interval.
177′0″-178′0″	4.88	Sand, dark greenish-brown; same as 176′0″-177′0″ interval.
178′0″-179′0″	5.43	Sand, dark greenish-brown; same as 177′0″-178′0″ interval.
179′0″-180′6″	5.43	Sand, dark greenish-brown; same as 178′0″-179′0″ interval with scattered spots of dark olive-green clay in the lower 6 inches of the interval. Foraminifera rare, no Ostracoda.
180′6″-185′4″		No sample.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
185′4″-186′4″	3.58	Sand and clay, dark greenish-brown; 65 percent very fine angular to subangular clear quartz sand, 20 percent dark olive-green clay, 15 percent very fine to fine-grained light-brown to black phosphate. Trace of medium subangular to subrounded clear quartz sand, subrounded to rounded frosted quartz sand, coarse-sand to medium-gravel-size particles of dark-brown to black phosphate, light-gray limestone aggregates, very fine-grained light to dark-green glauconite. Foraminifera rare, no Ostracoda.
186′4″-187′6″	3.58	Sand and clay, dark greenish-brown; same as 185′4″-186′4″ interval with no fine-grained glauconite. Trace of amber. No microfossils.
187′6″-188′0″	0.04	Limestone and clay, light greenish-gray; this interval consists of poorly indurated limestone interbedded with thin layers of light to dark olive-green sandy clay. For entire interval: 70 percent tan to light-gray very fine crystalline limestone, 20 percent light to dark olive-green clay, 10 percent very fine to medium angular to subangular clear quartz sand. Trace of coarse subangular to subrounded clear quartz sand, very fine to medium-grained light to dark-brown phosphate. Foraminifera very rare, no Ostracoda.
188′0″-189′0″	0.04	Limestone, light greenish-gray; very fine crystalline tan to light greenish-gray well indurated limestone. Trace of fine to medium-grained dark-brown to black phosphate. Diatoms present in lower 2 inches of interval. No Foraminifera or Ostracoda.
189′0″-200′0″	0.77	Diatomaceous clay, light olive-green; 85 percent very light-weight light olive-green clay, 15 percent of sample is composed of diatoms. Trace of fine to medium-grained light to dark-brown phosphate, medium-grained subangular to subrounded clear quartz sand. Sponge spicules very rare, no Foraminifera or Ostracoda.
200′0″-201′0″	6.58	Diatomaceous clay, light olive-green; same as 189′0″-200′0″ interval with 5 percent increase in diatoms and corresponding decrease in clay. Fine to medium-grained phosphate prominent, no quartz sand. Sponge spicules very rare, no Foraminifera or Ostracoda.
201′0″-203′0″	6.58	Phosphatic clay and sand, light olive-green; 60 percent light-weight light olive-green diatomaceous clay, same as 200′0″-201′0″ interval, 30 percent fine to medium-grained light-brown to black phosphate, 10 percent fine to medium-grained subangular to subrounded clear quartz sand. Trace of coarse-grained light-gray to dark-brown phosphate. Diatoms very abundant, sponge spicules common, no Foraminifera or Ostracoda.
203′0″-204′0″	21.4	Phosphatic sand and clay, dark

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		greenish-brown; the upper 6 inches of this interval contains layers of dark olive-green clay interbedded with phosphatic sand. The lower 6 inches is mainly phosphatic sand. For entire interval: 25 percent dark olive-green clay, 20 percent fine to medium-grained subangular to subrounded clear quartz sand, 55 percent fine to medium-grained light-gray to dark-brown phosphate. Trace of rose quartz, coarse-grained light to dark-brown phosphate, very fine-grained light-green glauconite. Diatoms and sponge spicules very common, no Foraminifera or Ostracoda.
204′0″-207′0″	21.1	Phosphatic clay and sand, medium greenish-brown; 40 percent medium olive-green calcareous clay, 30 percent fine to medium-grained light-brown to black phosphate, 20 percent fine to medium angular to subangular clear quartz sand, 10 percent light-gray weathered phosphate. Trace of coarse subrounded clear quartz sand, coarse-grained light to dark-brown phosphate, medium subrounded frosted quartz sand. Trace of very fine-grained light-green glauconite. Diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
207′0″-208′0″	15.1	Phosphatic clay and sand, medium greenish-gray; same as 204′0″-207′0″ interval.
208′0″-209′0″	15.1	Phosphatic clay and sand, medium greenish-gray; same as 207′0″-208′0″ interval with Foraminifera, diatoms, and sponge spicules rare, no Ostracoda.
209′0″-210′0″	15.1	Phosphatic clay and sand, medium greenish-gray; same as 208′0″-209′0″ interval with Foraminifera very rare, no diatoms, sponge spicules, or Ostracoda.
210′0″-211′0″	8.34	Phosphatic clay and sand, medium greenish-gray; same as 209′0″-210′0″ interval with diatoms and sponge spicules very rare, no Foraminifera or Ostracoda.
211′0″-212′0″	8.34	Phosphatic clay and sand, medium olive-green; this interval consists of layers of medium olive-green clay interbedded with phosphatic sand. For entire interval: 60 percent medium olive-green calcareous clay, 15 percent fine to medium subangular to subrounded clear quartz sand, 15 percent fine to medium-grained light-gray to dark-brown phosphate, 10 percent light-gray weathered phosphate. Trace of coarse-sand to fine-gravel-size particles of light to dark-brown phosphate, light-gray limestone aggregates. Diatoms very abundant, sponge spicules common, no Foraminifera or Ostracoda.
212′0″-213′2″	11.4	Phosphatic sandy limestone, medium greenish-gray; the upper 7 inches of this interval is phosphatic sandy limestone, poorly indurated, lithology as follows: 50 percent fine crystalline light greenish-gray limestone, 25 percent fine to medium angular to subangular clear quartz sand, 25 percent fine to medium-grained light to dark-brown phosphate. Light-gray weathered phosphate prominent. Trace of coarse subangular clear quartz sand, coarse subrounded frosted quartz sand, coarse-grained light-gray to dark-brown phosphate. The lower 5 inches of this interval is phosphatic sand and clay, same as 213′2″-214′0″ interval. For entire interval: Foraminifera and sponge spicules rare, no diatoms or Ostracoda.
213′2″-214′0″	16.6	Phosphatic sand and clay, medium greenish-gray; 40 percent fine-grained light to dark-brown phosphate, 30 percent fine to medium angular to subangular clear quartz sand, 30 percent medium olive-green clay. Trace of coarse-sand to medium-gravel-size particles of light to dark-brown phosphate, light-gray weathered phosphate. Diatoms and sponge spicules common, Foraminifera rare, no Ostracoda.
214′0″-215′0″	16.6	Phosphatic sand and clay, medium greenish-gray; same as 213′2″-214′0″ interval with diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
215′0″-215′6″	10.3	Phosphatic sand and clay, medium greenish-gray; same as 214′0″-215′0″ interval with no coarse-grained phosphate. Diatoms, sponge spicules, and Foraminifera rare, no Ostracoda.
215′6″-216′2″	10.3	Phosphatic sand and clay, medium greenish-gray; same as 215′0″-215′6″ interval with diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
216′2″-218′5″	5.76	Phosphatic sandy limestone, medium greenish-gray; 70 percent fine crystalline light greenish-gray well indurated limestone, 20 percent fine-grained light to dark-brown phosphate, 10 percent fine to medium angular to subangular clear quartz sand. Foraminifera very rare, no diatoms, sponge spicules, or Ostracoda.
218′5″-219′5″	10.9	Phosphatic sand and clay, medium greenish-gray; 55 percent medium subangular to subrounded clear quartz sand, 20 percent medium olive-green clay, 15 percent medium-grained light-brown to black phosphate, 10 percent light-gray weathered phosphate. Trace of coarse subrounded clear quartz sand, coarse-grained light to dark-brown phosphate. Diatoms and Foraminifera very rare, no Ostracoda.
219′5″-220′5″	10.9	Phosphatic sand and clay, medium

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		greenish-gray; same as 218′5″-219′5″ interval.
220′5″-221′0″	13.8	Phosphatic sand and clay, medium greenish-gray; same as 219′5″-220′5″ interval with 5 percent increase in medium-grained phosphate and corresponding decrease in medium quartz sand. Foraminifera rare, no diatoms or Ostracoda.
221′0″-231′9″		No sample.
231′9″-232′9″	9.81	Sand and clay, medium greenish-gray; 65 percent very fine to fine angular to subangular clear quartz sand, 20 percent medium olive-green clay, 15 percent very fine to fine-grained light to dark-brown phosphate. Trace of medium subangular to sub-rounded clear quartz sand, medium-grained dark-brown to black phosphate. Phosphoritized diatoms rare, no Foraminifera or Ostracoda.
232′9″-233′9″	9.81	Phosphatic sand and clay, medium greenish-gray; same as 231′9″-232′9″ interval with 5 percent increase in fine-grained phosphate and corresponding decrease in fine quartz sand. Foraminifera very rare, no diatoms or Ostracoda.
233′9″-234′9″	9.68	Phosphatic sand and clay, medium greenish-gray; same as 232′9″-233′9″ interval with diatoms and Foraminifera very rare, no Ostracoda.
234′9″-235′9″	9.68	Phosphatic sand and clay, medium olive-green; same as 233′9″-234′9″ interval with sponge spicules very rare, no Foraminifera, or Ostracoda.
235′9″-237′0″	5.78	Phosphatic sand and clay, medium greenish-gray. The upper 10 inches of this interval is phosphatic sand and clay, same as 234′9″-235′9″ interval. The lower 5 inches of the interval contains layers of medium olive-green slightly calcareous clay, same as 237′0″-238′0″ interval. For entire interval: Diatoms abundant, sponge spicules common, no Foraminifera or Ostracoda.
237′0″-238′0″	5.78	Diatomaceous clay and phosphatic sand, light olive-green; this interval is chiefly light olive-green diatomaceous clay with a few scattered layers of phosphatic sand. For entire interval: 70 percent light-weight light olive-green diatomaceous clay, 20 percent very fine to fine angular to subangular clear quartz sand, 10 percent very fine to fine-grained light to dark-brown phosphate. Coarse-grained light to dark-brown phosphate prominent. Diatoms very abundant, no Foraminifera, sponge spicules, or Ostracoda.
238′0″-239′3″	5.78	Phosphatic sand and diatomaceous clay, light greenish-gray; this interval consists of alternating layers of light-weight, light olive-green diatomaceous clay and phosphatic sand. For entire interval: 55 percent light-weight, light olive-green diatomaceous clay, 20 percent very fine to fine angular to subangular clear quartz sand, 15 percent very fine to fine-grained light-brown to black phosphate, 10 percent of sample is composed of diatoms. Medium-grained dark-brown to black phosphate prominent. Trace of medium subangular to sub-rounded clear quartz sand. No Foraminifera, Ostracoda, or sponge spicules.
239′3″-247′0″	7.44	Phosphatic clay, medium olive-green; 45 percent dark olive-green slightly calcareous clay, 35 percent very fine-grained dark-brown phosphate, 10 percent fine to coarse-grained dark-brown to black phosphate, 10 percent fine to medium angular to subangular clear quartz sand. Trace of fine to medium white to light-gray broken shell fragments. Diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
247′0″-248′0″	8.40	Phosphatic clay, medium olive-green; same as 239′3″-247′0″ interval with decrease in fine to coarse-grained phosphate to only a trace. Corresponding increase in very fine-grained phosphate. Sponge spicules common, Foraminifera very rare, no diatoms or Ostracoda.
248′0″-249′0″	8.40	Phosphatic clay, medium olive-green; same as 247′0″-248′0″ interval with no shell fragments. Sponge spicules common, Foraminifera rare, no diatoms or Ostracoda.
249′0″-250′0″	7.83	Phosphatic clay, dark olive-green; same as 248′0″-249′0″ interval with Foraminifera (chiefly phosphoritized) abundant, sponge spicules rare, no diatoms or Ostracoda.
250′0″-251′0″	7.83	Phosphatic clay, dark olive-green; same as 249′0″-250′0″ interval with coarse-sand to fine-gravel-size particles of dark-brown to black phosphate prominent. Sponge spicules and phosphoritized Foraminifera rare, no diatoms or Ostracoda.
251′0″-252′3″	7.83	Phosphatic clay, dark olive-green; same as 250′0″-251′0″ interval with diatoms and sponge spicules very rare, no Foraminifera or Ostracoda.
252′3″-253′0″	2.15	Phosphatic calcareous clay, medium greenish-gray; 80 percent highly calcareous medium greenish-gray clay, 20 percent very fine to medium-grained reddish-brown to dark-brown phosphate. Particles of fine crystalline limestone very prominent. Sponge spicules and phosphoritized Foraminifera common, no diatoms or Ostracoda.
253′0″-256′5″	11.2	Limestone, medium-gray; very fine

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		crystalline well indurated limestone. Trace of fine-grained dark-brown to black phosphate. No microfossils.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
256′5″-257′0″	11.2	Shell limestone, medium-gray. Well indurated fine crystalline medium to dark-gray limestone. Trace of very fine-grained dark-brown to black phosphate. Most of this interval consists of fossil casts and molds. Diatoms very rare, no Foraminifera or Ostracoda.
257′0″-259′0″	0.03	Limestone, white. Chalk-white very fine crystalline limestone, poorly indurated. Trace of very fine subangular to subrounded clear quartz sand, fine to medium-grained dark-brown phosphate. This interval is highly weathered, with a shell of very soft chalky limestone developed on the fresh rock. Diatoms very rare, no Foraminifera or Ostracoda.

Pamlico Beach quadrangle PB-4-GL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
161′2″-162′2″	5.02	Sand, medium greenish-gray; 80 percent fine angular to subangular clear quartz sand, 10 percent fine-grained light-brown to black phosphate, 10 percent medium subangular to subrounded clear quartz sand. Trace of medium-grained dark-brown to black phosphate, fine frosted subangular quartz gravel. Foraminifera rare, no Ostracoda.
162′2″-163′3″	5.02	Sand, medium greenish-gray; same as 161′2″-162′2″ interval.
163′2″-164′2″	5.02	Sand, medium greenish-gray; same as 162′2″-163′2″ interval.
164′2″-165′0″	5.02	Sand, medium greenish-gray; same as 163′2″-164′2″ interval.
165′0″-166′0″	4.42	Sand, medium greenish-gray; same as 164′2″-165′0″ interval with no microfossils.
166′0″-167′0″	4.42	Sand, medium greenish-gray; same as 165′0″-166′0″ interval.
167′0″-168′0″	4.42	Sand, medium greenish-gray; same as 166′0″-167′0″ interval with Foraminifera and sponge spicules rare, no Ostracoda.
168′0″-189′6″		No sample.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
189′6″-190′4″	5.18	Phosphatic sand and clay, dark greenish-brown; 50 percent medium olive-green clay, 30 percent very fine to fine angular to subangular clear quartz sand, 20 percent very fine to medium light-brown to black phosphate. Medium to coarse subrounded to rounded clear to frosted quartz sand and medium to coarse-grained light-brown to black phosphate prominent. Foraminifera and Ostracoda rare.
190′4″-191′4″	15.2	Phosphatic clay, dark greenish-brown; 45 percent very fine to fine-grained light-brown to black phosphate, 40 percent dark olive-green clay, 10 percent coarse-sand to medium-gravel-size particles of dark-brown to black phosphate, 5 percent fine to medium subangular to subrounded clear quartz sand. Foraminifera rare, no Ostracoda.
191′4″-192′4″	15.2	Phosphatic clay, dark greenish-brown; same as 190′4″-191′4″ interval.
192′4″-193′10″	15.2	Phosphatic clay, dark greenish-brown; same as 191′4″-192′4″ interval with 5 percent increase in fine to medium quartz sand and corresponding decrease in fine-grained phosphate. Foraminifera rare, no Ostracoda.
193′10″-194′6″	13.1	Phosphatic clay, dark greenish-brown. The upper 3 inches of this interval is the same as 192′4″-193′10″ interval. The interval 191′4″-194′3″ is composed of light greenish-white calcareous clay. The lower 3 inches of the interval is phosphatic sand and shell, same as 194′6″-195′6″ interval. Foraminifera common, no Ostracoda.
194′6″-195′6″	13.1	Phosphatic sand and shell, greenish-white mottled; 55 percent fine to medium-grained light-brown to black phosphate, 25 percent fine to medium white broken shell fragments, 10 percent dark olive-green clay, 10 percent medium subangular to subrounded clear quartz sand. Trace of fine-gravel-size particles of light-gray to dark-brown phosphate. Foraminifera common, no Ostracoda.
195′6″-196′1″	13.1	Phosphatic sand and shell, greenish-white mottled; same as 194′6″-195′6″ interval with Foraminifera very abundant, no Ostracoda.
196′1″-196′8″	2.44	Limestone, white; 85 percent very fine-grained light gray to white poorly indurated limestone, 15 percent fine to medium subangular to subrounded clear quartz sand. Trace of medium white broken shell fragments, fine to medium-grained light to dark-brown phosphate. Foraminifera rare, no Ostracoda.
196′8″-200′0″	0.27	Limestone, dark-gray to light greenish-gray; this interval is divided into two distinct rock types. The upper 2 inches of the interval consists of dark-gray sandy limestone, well indurated, composition as follows: 55 percent fine to medium subangular to subrounded clear quartz sand, 45 percent dark-gray

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		very fine crystalline limestone matrix. Casts and molds of fossils very prominent. The lower 2 inches of the interval consists of very fine crystalline light-gray well indurated limestone with a greenish cast, containing scattered vugs lined with calcite crystals. For entire interval: Foraminifera rare, no Ostracoda.
200′0″-201′0″	0.39	Calcareous clay, light greenish-white; 60 percent very light-green highly calcareous clay, 40 percent medium-gravel to coarse-sand-size poorly indurated aggregates of white calcareous clay. Trace of fine to coarse subrounded clear quartz sand, medium-grained light-brown phosphate, black clay. Foraminifera very rare, no Ostracoda.
201′0″-202′0″	1.16	Calcareous clay, light olive-green; 90 percent light olive-green calcareous clay, 5 percent very fine to fine-grained angular to subangular clear quartz sand, 5 percent very fine to fine-grained dark-brown to black phosphate. Light-gray weathered phosphate prominent. Trace of light-gray very fine crystalline limestone, black clay. Foraminifera very rare, no Ostracoda.
202′0″-203′0″	1.16	Calcareous clay, light olive-green; same as 201′0″-202′0″ interval with diatoms and Foraminifera rare, no Ostracoda.
203′0″-204′0″	1.65	Clay, light olive-green; 90 percent light olive-green calcareous clay, 10 percent very fine to fine-grained light-brown to black phosphate. Trace of fine to medium-grained dark to light-green glauconite, fine to medium subangular to subrounded clear quartz sand, fine white broken shell fragments. No microfossils.
204′0″-205′0″	1.65	Clay, light olive-green; same as 203′0″-204′0″ interval with Foraminifera very rare, no Ostracoda.
205′0″-205′8″	1.65	Calcareous clay and phosphatic sand, light to medium olive-green; this interval consists of light to medium olive-green clay interbedded with thin layers of phosphatic sand. For entire interval: 70 percent light to medium olive-green calcareous clay, 20 percent very fine to fine-grained dark-brown to black phosphate, 10 percent very fine to fine angular to subangular clear quartz sand. Trace of medium subangular clear quartz sand, medium-grained dark-brown to black phosphate. No microfossils.
205′8″-206′9″	15.5	Phosphatic sand and clay, medium olive-green; the upper three inches of this interval is calcareous clay and phosphatic sand, same as 205′0″-205′8″ interval. The composition of the lower 10 inches is as follows: 50 percent very fine to medium-grained light-brown to black phosphate, 30 percent medium olive-green slightly calcareous clay, 10 percent very fine to medium subangular to subrounded clear quartz sand, 10 percent fine to medium-grained light-brown to light-gray weathered phosphate. Trace of coarse-grained dark-brown to black phosphate, light-gray to white fine-gravel-size particles of limestone. No microfossils.
206′9″-207′2″	0.60	Calcareous clay, white; 85 percent white highly calcareous clay, 10 percent Foraminifera, 5 percent fine-grained dark-brown to black phosphate. Trace of fine subangular to subrounded clear quartz sand. Sponge spicules rare, no Ostracoda.
207′2″-212′5″	11.8	Phosphatic sand and clay, dark to light olive-green; this interval consists of dark olive-green calcareous clay. For entire interval: 50 percent fine to medium-grained light-brown to black phosphate, 30 percent light olive-green clay, 10 percent light-gray to light-brown weathered phosphate, 10 percent fine to medium subangular to subrounded clear quartz sand. Medium-grained light-brown to black phosphate prominent. Trace of fine broken shell fragments, coarse-sand-size aggregates of white limestone. Foraminifera abundant, no Ostracoda.
212′5″-213′5″	11.8	Phosphatic sand and clay, dark to light olive-green; same as 207′2″-212′5″ interval.
213′5″-214′5″	18.8	Phosphatic sand and clay, dark greenish-brown; this interval consists of coarse phosphatic sand interbedded with very dark greenish-black clay. For entire interval: 50 percent fine to medium-grained light-brown to black phosphate, 30 percent dark greenish-black clay, 20 percent fine to medium angular to subangular clear quartz sand. Light-gray weathered phosphate prominent. Trace of coarse-grained dark-brown to black phosphate. Foraminifera very rare, no Ostracoda.
214′5″-215′0″	18.8	Phosphatic sand, dark greenish-brown; 60 percent fine to medium-grained light-brown to black phosphate, 30 percent fine to medium angular to subangular clear quartz sand, 10 percent dark greenish-black clay. Trace of coarse-sand to medium-gravel-size particles of dark-brown to black phosphate. Fine to medium-grained light-brown to light-gray weathered phosphate prominent. No microfossils.
215′0″-216′0″	18.8	Phosphatic sand, dark greenish-brown; same as 214′5″-215′0″ interval.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
216′0″-217′0″	19.5	Phosphatic sand, dark greenish-brown; same as 215′0″-216′0″ interval with Foraminifera very rare, no Ostracoda.
217′0″-218′0″	19.5	Phosphatic sand, dark greenish-brown; same as 216′0″-217′0″ interval.
218′0″- Grab sample	19.5	Phosphatic sand, dark greenish-brown; same as 217′0″-218′0″ interval with Foraminifera common, no Ostracoda.
218′0″-219′0″	19.5	Phosphatic sand, dark greenish-brown; same as 218′0″ grab sample with no microfossils.
219′0″-219′10″	19.5	Phosphatic sand, dark greenish-brown; same as 218′0″-219′0″ interval with 5 percent increase in quartz sand and corresponding decrease in phosphate. No microfossils.
219′10″-220′8″	14.2	Phosphatic sand, dark greenish-brown; same as 219′0″-219′10″ interval with Foraminifera common, no Ostracoda.
220′8″-222′1″	14.1	Phosphatic sand, dark greenish-brown; same as 219′10″-220′8″ interval with slight increase in coarse-sand to fine-gravel-size phosphate. No microfossils.
222′1″-223′5″	7.97	Phosphatic sandy limestone, medium greenish-gray; 40 percent fine crystalline light-gray well indurated limestone, 35 percent fine to medium angular to subangular clear quartz sand, 25 percent fine to medium-grained light to dark-brown phosphate. Fine-gravel-size particles of dark-brown to black phosphate prominent. No microfossils.
223′5″-224′5″	10.8	Phosphatic sand and clay, light greenish-gray; 45 percent fine to medium subangular to subrounded clear quartz sand, 35 percent fine to medium-grained light-brown to black phosphate, 20 percent light olive-green clay. Trace of coarse-grained dark-brown to black phosphate, coarse subrounded clear quartz sand, light-gray weathered phosphate. Foraminifera very rare, no Ostracoda.
224′5″-225′5″	10.8	Phosphatic sand and clay, light greenish-gray; same as 223′5″-224′5″ interval with no microfossils.
225′5″-226′8″	13.8	Phosphatic sand and clay, light greenish-gray; Same as 224′5″-225′5″ interval with Foraminifera very rare, no Ostracoda.
226′8″-237′0″		No sample.
237′0″-238′10″	0.56	Phosphatic sand and clay, medium greenish-gray; 40 percent light greenish-gray clay, 40 percent very fine angular to subangular clear quartz sand, 20 percent very fine to fine light-brown to black phosphate. Medium subangular to subrounded clear quartz sand and medium-grained dark-brown phosphate prominent. Trace of medium frosted quartz sand. Sponge spicules rare, Foraminifera common, no Ostracoda.
238′10″-239′0″	0.56	Sandy limestone, medium-gray; 65 percent medium-gray very fine crystalline well indurated limestone, 35 percent fine to medium subangular to subrounded clear quartz sand. Trace of fine to medium-grained dark-brown to black phosphate. Fossil casts and molds compose much of this interval. No microfossils.
239′0″-240′0″	4.49	Phosphatic sand and clay, medium greenish-brown; 60 percent very fine to fine angular to subangular clear quartz sand, 20 percent very fine to fine-grained light-brown to black phosphate, 20 percent medium olive-green clay. Trace of coarse-sand to fine-gravel-size particles of dark-brown to black phosphate, coarse subrounded clear quartz sand, light-gray weathered phosphate, very fine-grained light-green glauconite. Foraminifera very rare, no Ostracoda.
240′0″-241′0″	4.49	Phosphatic sand and clay, medium greenish-brown; same as 239′9″-240′0″ interval with Foraminifera and sponge spicules rare, no Ostracoda.
241′0″-242′0″	4.49	Phosphatic sand and clay, medium greenish-brown; same as 240′0″-241′0″ interval.
242′0″-243′0″	4.49	Phosphatic sand and clay, medium greenish-brown; same as 241′0″-242′0″ interval with diatoms and sponge spicules rare, no Foraminifera or Ostracoda.
243′0″-243′6″	8.39	Phosphatic sand and clay, medium olive-green; 40 percent very fine to fine angular to subangular clear quartz sand, 30 percent light olive-green clay, 25 percent very fine to fine-grained light-brown to black phosphate, 5 percent coarse-sand to medium-gravel-size particles of light-brown to black phosphate. Medium subrounded clear to frosted quartz sand prominent. Trace of light-gray weathered phosphate. Diatoms and sponge spicules abundant, no Foraminifera or Ostracoda.
243′6″-244′6″	8.39	Phosphatic sand and clay, medium olive-green; This interval consists of alternating layers of light olive-green clay and medium olive-green phosphatic sand. For entire interval: 60 percent light olive-green clay, 20 percent fine angular to subangular clear quartz sand, 20 percent fine to medium-grained light to dark-brown phosphate. Medium subrounded clear to frosted quartz sand and coarse-grained dark-brown to black phosphate prominent. Diatoms and sponge

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		spicules rare, no Foraminifera or Ostracoda.
244′6″-245′6″	8.39	Phosphatic clay, medium olive-green; this interval consists of alternating layers of light olive-green clay and phosphatic sand. For entire interval: 60 percent light olive-green clay, 20 percent fine to meduim-grained light-gray weathered phosphate, 10 percent fine to medium-grained light-brown to black phosphate, 10 percent medium subrounded clear quartz sand. Diatoms and sponge spicules common, no Foraminifera or Ostracoda.
245′6″-247′0″	8.39	Phosphatic sand and clay, medium greenish-brown; 40 percent fine to medium angular to subangular clear quartz sand, 35 percent fine to medium-grained light to dark-brown phosphate, 15 percent light olive-gray weathered phosphate. Trace of medium subrounded clear quartz sand, coarse-sand to fine-gravel-size particles of light-brown to black phosphate. Diatoms and sponge spicules common, no Foraminifera or Ostracoda.
247′0″-248′0″	15.1	Phosphatic sand and clay, medium greenish-brown; same as 245′6″-247′0″ interval with 10 percent decrease in weathered phosphate, 5 percent increase in fine to medium-grained phosphate, 5 percent increase in fine to medium quartz sand. Trace of very fine-grained dark to light-green glauconite. Diatoms and sponge spicules very rare, no Foraminifera or Ostracoda.
248′0″-249′0″	15.1	Phosphatic sand and clay, medium greenish-brown; same as 247′0″-248′0″ interval with sponge spicules and Foraminifera very rare, no diatoms or Ostracoda.
249′0″-250′0″	15.1	Phosphatic sand and clay, medium greenish-brown; same as 248′0″-249′0″ interval with slight increase in coarse-sand to fine-gravel-size quartz and phosphate. Sponge spicules very rare, no Foraminifera, diatoms, or Ostracoda.
250′0″-251′6″	15.1	Phosphatic sand and clay, medium greenish-brown; same as 249′0″-250′0″ interval with no microfossils.
251′6″-252′6″	15.2	Phosphatic sand and clay, medium greenish-brown; same as 250′0″-251′6″ interval.
252′6″-253′8″	15.2	Phosphatic sand and clay, medium greenish-brown; same as 251′6″-252′6″ interval.
253′8″-254′8″	15.2	Phosphatic sand and clay, medium greenish-brown; same as 252′6″-253′8″ interval.
254′8″-255′6″	2.53	Calcareous clay and phosphatic sand, light olive-green to dark greenish-brown; this interval consists of alternating 1½″ to 2″ layers of light olive-green clay and dark greenish-brown phosphatic sand. For entire interval: 55 percent light olive-green calcareous clay, 20 percent coarse-sand to medium-gravel-size aggregates of light to medium-gray fine crystalline limestone, 15 percent medium subangular to subrounded clear quartz sand, 15 percent fine to medium-grained light-brown to black phosphate. No microfossils. The lower 1½″ of this interval is poorly indurated.
255′6″-256′0″	1.00	Limestone, light greenish-gray; 80 percent light greenish-gray very fine crystalline poorly indurated limestone, 10 percent fine to medium subangular to subrounded clear quartz sand, 10 percent very fine to medium-grained light-brown to black phosphate. Coarse-grained light-brown to black phosphate prominent. Foraminifera very rare, no Ostracoda.
256′0″-257′0″	10.6	Sand and clay, dark greenish-brown; 55 percent fine to medium-grained angular to subangular clear quartz sand, 30 percent light olive-green clay, 15 percent fine to medium-grained light to dark-brown phosphate. Medium subrounded clear to frosted quartz sand and coarse-grained dark-brown to black phosphate prominent. Trace of rose quartz, fossil wood. Foraminifera rare, no Ostracoda.
257′0″-258′0″	10.6	Sand and clay, dark greenish-brown; same as 256′0″-257′0″ interval with 5 percent decrease in phosphate and corresponding increase in fine to medium quartz sand. No microfossils.
258′0″-259′0″	10.6	Sand and clay, dark greenish-brown; same as 257′0″-258′0″ interval with Foraminifera very rare, no Ostracoda.
259′0″-260′0″	10.6	Sand and clay, dark greenish-brown; same as 258′0″-259′0″ interval with no microfossils.
260′0″-261′8″	10.6	Sand and clay, dark greenish-brown; same as 259′0″-260′0″ interval.
261′8″-262′8″	10.6	Sand and clay, dark greenish-brown; same as 260′0″-261′8″ interval with Foraminifera very rare, no Ostracoda.
262′8″-263′8″	5.95	Sand and clay, dark olive-green; 45 percent fine to medium angular to subangular clear quartz sand, 35 percent dark olive-green clay, 15 percent very fine to medium light-brown to black phosphate, 5 percent coarse subangular to subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.
263′8″-264′8″	5.95	Sand and clay, dark olive-green; same as 262′8″-263′8″ interval with 5 percent increase in coarse quartz sand and corresponding decrease in

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		phosphate. Foraminifera very rare, no Ostracoda.
264′8″-265′9″	5.95	Clay and sand, dark olive-green; this interval consists of dark olive-green clay with scattered thin layers of phosphatic sand. For entire interval: 70 percent dark olive-green clay, 20 percent fine to medium subangular to subrounded clear quartz sand, 10 percent very fine to medium-grained light to dark-brown phosphate. Trace of coarse subrounded clear to frosted quartz sand, coarse-sand to medium-gravel-size particles of light-gray to dark-brown phosphate. No microfossils.
265′9″-266′9″	2.70	Clay and sand, dark olive-green; same as 264′8″-265′9″ interval with Foraminifera very rare, no Ostracoda.
266′9″-267′9″	2.70	Clay and sand, dark olive-green; same as 265′9″-266′9″ interval.
267′9″-268′8″	2.70	Clay, dark olive-green; this interval consists of dark olive-green clay with a few scattered spots of phosphatic sand and clay, same as 268′8″-273′2″ interval. For entire interval: 90 percent dark olive-green clay, 5 percent fine to medium angular to subangular clear quartz sand, 5 percent fine-sand to medium-gravel-size particles of light-brown to black phosphate. Trace of coarse subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.
268′8″-273′2″	0.63	Phosphatic clay and sand, medium olive-green; 40 percent medium olive-green highly calcareous clay, 40 percent very fine to coarse-grained light to dark-brown phosphate, 20 percent fine to medium angular to subangular clear quartz sand. Fine to medium-gravel-size particles of dark-brown to black phosphate prominent. Foraminifera rare, no Ostarcoda.

Pinetown quadrangle PI-1-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
100′0″-102′8″	1.01	Shell, clay and sand, medium greenish-gray; 30 percent medium to very coarse white broken shell fragments, 30 percent medium-gray calcareous clay, 20 percent fine subangular to subrounded clear quartz sand, 10 percent very fine to fine white broken shell fragments, 10 percent fine-grained dark-brown to black phosphate. Fine-grained light-green glauconite prominent. *Turritella* fragments common. Foraminifera common, no Ostracoda.
102′8″-106′3″	0.34	Clay, light greenish-gray; light greenish-gray calcareous clay. Fine to medium white broken shell fragments prominent. Trace of fine angular to subangular clear quartz sand, fine-grained dark-brown to black phosphate, fine-grained light-green glauconite. Foraminifera common, Ostracoda rare.
106′3″-108′0″	0.19	Clay, light greenish-gray; 90 percent light greenish-gray calcareous clay, 10 percent fine to medium white broken shell fragments. Trace of very fine angular to subangular clear quartz sand, fine-grained black phosphate. Small *Turritella* and *Turritella* fragments common. Foraminifera abundant, Ostracoda rare.
108′0″-110′0″	0.19	Clay and shell, gray-white mottled; 80 percent light greenish-gray calcareous clay, 20 percent medium to coarse white broken shell fragments. Trace of very fine angular to subangular clear quartz sand, pyrite aggregates, black clay. Large *Turritella* common. Foraminifera abundant, Ostracoda rare.
110′0″-112′8″	0.33	Clay and shell, gray-white mottled; same as 108′0″-110′0″ interval with 10 percent increase in shell fragments and corresponding decrease in clay. Foraminifera abundant, Ostracoda rare.
112′8″-116″0′	1.67	Clay and shell, gray-white mottled; 55 percent medium-gray calcareous clay, 20 percent medium to coarse white broken shell fragments, 10 percent very fine to fine white broken shell fragments, 10 percent fine to medium subangular to subrounded clear quartz sand, 5 percent fine to medium-grained dark-brown to black phosphate. Trace of coarse-grained dark-brown phosphate, fine-grained light-green glauconite, rose quartz. Small *Turritella* and *Turritella* fragments common. Foraminifera abundant, Ostracoda rare.
116′0″-118′5″	4.12	Clay, sand and shell, gray-white-mottled; 35 percent medium-gray calcareous clay, 30 percent very fine to fine subangular to subrounded clear quartz sand, 20 percent medium to very coarse white broken shell fragments, 15 percent very fine to fine-grained dark-brown to black phosphate. Trace of medium rounded frosted quartz sand, medium-grained dark-brown phosphate, *Turritella* fragments. Foraminifera common, no Ostracoda.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
118′5″-120′10″	1.36	Limestone, medium-gray. The upper 6 inches of this interval consists of sandy medium-gray limestone, poorly indurated. The lower 1′10″ consists of shell limestone, well indurated. For entire interval: 70 percent medium-gray fine crystalline limestone, 20 percent fossil casts and molds, replaced by limestone, 10 percent very fine-grained

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		dark-brown to black phosphate. Fine angular to subangular clear quartz sand prominent. Foraminifera very rare, no Ostracoda.
120′10″-121′10″	5.77	Phosphatic sand, medium greenish-gray; 50 percent fine subangular to subrounded clear quartz sand, 25 percent fine-grained light to dark-brown phosphate, 10 percent medium subrounded clear to frosted quartz sand, 10 percent medium-gray calcareous clay, 5 percent coarse-sand to fine-gravel-size particles of dark-gray limestone. No microfossils.
121′10″-124′1″	5.77	Phosphatic sand, light greenish-brown; 40 percent very fine-grained light to dark-brown phosphate, 30 percent fine subangular to subrounded clear quartz sand, 15 percent medium-gray calcareous clay, 10 percent very fine to fine white broken shell fragments, 5 percent medium to coarse white broken shell fragments. Trace of coarse-grained light to dark-gray phosphate. Foraminifera rare, no Ostracoda.
124′1″-125′1″	3.99	Phosphatic clay, medium olive-green; 55 percent medium olive-green calcareous clay, 35 percent very fine-grained light to dark-brown phosphate, 10 percent very fine to fine subangular to subrounded clear quartz sand. Fine white broken shell fragments, calcite and dolomite rhombohedrons prominent. Trace of medium to coarse-grained dark-gray phosphate. Foraminifera common, no Ostracoda.
125′1″-126′10″	3.99	Phosphatic clay, medium olive-green; same as 124′1″-125′1″ interval with decrease in shell fragments to a trace. Trace of very fine-grained light-green glauconite. No microfossils.
126′10″-128′0″	12.7	Sand and clay, light greenish-gray; 40 percent fine subangular to subrounded clear quartz sand, 30 percent medium-gray calcareous clay, 10 percent very fine to fine-grained dark-brown to black phosphate, 10 percent very fine to fine white broken shell fragments, 5 percent medium to coarse white broken shell fragments, 5 percent medium to coarse-grained light-gray to black phosphate. Foraminifera abundant, radiolaria rare, no Ostracoda.
128′0″-131′6″	1.67	Sandy limestone, medium to light-gray. The upper 6 inches of this interval consists of well indurated medium-gray sandy limestone, with a few fossil casts and molds. The lower 3 inches is composed of light-gray sandy limestone, poorly indurated. For entire interval: 50 percent very fine to fine subangular clear quartz sand, 40 percent medium to light-gray limestone matrix, 10 percent fine-grained dark-brown to black phosphate. Trace of medium-grained dark-gray to black phosphate, rose quartz. Foraminifera rare, no Ostracoda.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
131′6″-133′0″	2.07	Sandy limestone, white, poorly indurated; 55 percent soft white limestone matrix, 45 percent fine subangular to subrounded clear quartz sand. Trace of medium to coarse white to light-gray broken shell fragments, fine-grained dark-green glauconite. Foraminifera very rare, no Ostracoda.
133′0″-136′0″	0.37	Sandy limestone, medium greenish-gray, well indurated; 65 percent very fine crystalline medium-gray limestone matrix, 35 percent very fine to fine subangular to subrounded clear quartz sand. Fine-grained dark to light-green glauconite prominent. Foraminifera very rare, no Ostracoda.

Pinetown quadrangle PI-5-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
90′0″-95′0″	0.21	Clay, sand and shell, light greenish-gray; 80 percent light-gray clay, 10 percent very fine to fine subangular clear quartz sand, 10 percent fine to medium white to dark-gray broken shell fragments. Trace of fine-grained dark-brown to black phosphate, fine-grained bright-green glauconite. Small *Turritella* and *Turritella* fragments common. Foraminifera abundant, Ostracoda rare.
95′0″-100′0″	0.02	Clay, sand and shell light greenish-gray; same as 90′0″-95′0″ interval with trace of pyrite aggregates. Foraminifera abundant, no Ostracoda.
100′0″-105′0″	0.06	Clay, light greenish-gray; 90 percent medium-gray clay, 5 percent very fine to fine subangular to subrounded clear quartz sand, 5 percent very fine to fine white broken shell fragments. Trace of fine-grained dark to light-brown phosphate. Foraminifera abundant, Ostracoda rare.
105′0″-109′5″	0.02	Clay, medium greenish-gray; 85 percent medium-gray clay, 10 percent fine to medium white broken shell fragments, 5 percent very fine to fine subrounded clear quartz sand. Trace of light to dark-brown phosphate. Foraminifera abundant, no Ostracoda.
109′5″-114′5″	0.02	Clay, medium greenish-gray; same as 105′0″-109′5″ interval with trace of fine-grained bright-green glauconite, pyrite aggregates. Foraminifera very abundant, no Ostracoda.
114′5″-119′5″	0.27	Clay, medium greenish-gray; same as 109′5″-114′5″ interval with Fo-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		raminifera very abundant, diatoms rare, no Ostracoda.
119′5″-125′0″	3.70	Clay, medium greenish-gray; 80 percent medium-gray clay, 10 percent fine to medium white broken shell fragments, 10 percent fine to very fine subangular to subrounded clear quartz sand. Pyrite aggregates prominent. Trace of fine-grained bright-green glauconite, fine-grained dark to light-brown phosphate. Foraminifera abundant, Ostracoda rare, no diatoms.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
125′0″-127′0″	10.0	Phosphatic limestone, dark-gray, well indurated; 65 percent very fine crystalline dark-gray limestone, 30 percent very fine to fine-grained dark to light-brown phosphate, 5 percent very fine to fine angular to subangular clear quartz sand. Foraminifera very rare, no Ostracoda.
127′0″-130′5″		No sample.
130′5″-131′5″	7.10	Phosphatic limestone, dark-gray, well indurated; same as 125′0″-127′0″ interval.
131′5″-133′0″	12.4	Phosphatic sand, dark greenish-brown; 55 percent fine subangular to subrounded clear quartz sand, 40 percent fine to medium-grained light-brown to black phosphate, 5 percent fine to medium-gravel-size particles of dark-brown to black phosphate. Trace of fine-grained bright-green glauconite. Foraminifera very rare, no Ostracoda.
133′0″-134′0″	12.4	Phosphatic sand and clay, dark greenish-brown; 40 percent dark olive-green clay, 35 percent fine to medium-grained subangular to subrounded clear quartz sand, 25 percent fine to medium-grained light to dark-brown phosphate. Coarse-grained dark-brown phosphate prominent. Foraminifera rare, no Ostracoda.
134′0″-136′0″	12.4	Phosphatic sand, dark greenish-brown; 70 percent fine subangular to subrounded clear quartz sand, 20 percent fine-grained light to dark-brown phosphate, 10 percent fine to medium-gravel-size particles of light-brown to light-gray phosphate. Trace of frosted quartz sand, very fine-grained bright-green glauconite. Foraminifera very rare, no Ostracoda.
136′0″-136′6″	4.17	Phosphatic sandy limestone, well indurated, medium greenish-gray; 45 percent very fine crystalline dark-gray limestone, 40 percent fine to medium subangular to subrounded clear quartz sand, 15 percent very fine to fine-grained dark-brown phosphate. Frosted subrounded medium sand prominent. Trace of medium-grained dark-brown phosphate. Foraminifera very rare, no Ostracoda.
136′6″-138′10″	2.46	Phosphatic sandy limestone, well indurated, medium greenish-gray; same as 136′0″-136′6″ interval with 10 percent increase in very fine crystalline limestone and corresponding decrease in fine to medium quartz sand. Foraminifera very rare, no Ostracoda.
138′10″-139′10″	2.35	Sand, medium greenish-brown; 90 percent fine subangular to subrounded clear quartz sand, 5 percent medium subangular to subrounded frosted quartz sand, 5 percent fine to medium light-brown to dark-gray phosphate. Trace of fine-gravel-size dark-brown to black phosphate, calcite and dolomite rhombohedrons. Foraminifera very rare, no Ostracoda.
139′10″-140′10″	2.35	Sand and clay, medium greenish-gray; 70 percent fine subangular to subrounded clear quartz sand, 20 percent medium-gray clay, 10 percent fine to medium-grained light-brown to dark-gray phosphate. Trace of calcite and dolomite rhombohedrons, fine frosted subrounded quartz sand, black clay. Radiolaria and Foraminifera rare, no Ostracoda.
140′10″-142′6″	4.29	Phosphatic sand and clay, medium greenish-gray; 55 percent very fine to fine angular to subangular clear quartz sand, 25 percent medium-gray clay, 20 percent very fine to fine-grained light-brown to black phosphate. Trace of medium subrounded clear quartz sand, medium-grained light-gray phosphate, dolomite rhombohedrons. Radiolaria and Foraminifera very rare, no Ostracoda.
142′6″-143′6″	2.41	Phosphatic sand and clay, medium greenish-gray; same as 140′10″-142′6″ interval with 10 percent increase in phosphate and corresponding decrease in very fine to fine quartz sand. Trace of fine-gravel-size particles of light-brown phosphate. Radiolaria rare, no Foraminifera or Ostracoda.
143′6″-144′6″	2.41	Phosphatic clay and sand, medium olive-green; 40 percent medium olive-green clay, 30 percent very fine-grained light-brown to black phosphate, 30 percent very fine subangular to subrounded clear quartz sand. Trace of coarse subangular clear quartz sand, coarse-grained dark-gray to black phosphate, dolomite rhombohedrons. Radiolaria rare, no Foraminifera or Ostracoda.
144′6″-146′0″	2.41	Clay and sand, medium olive-green; 75 percent medium olive-green clay, 15 percent very fine subangular clear quartz sand, 10 percent very fine-grained light-brown to light-gray phosphate. Trace of fine subangular clear quartz sand, dolo-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		mite rhombohedrons. Radiolaria rare, no Foraminifera or Ostracoda.
146′0″-150′2″	0.98	Clay, medium olive-green; same as 144′6″-146′0″ interval with 10 percent increase in clay and 5 percent decrease in both phosphate and very fine quartz sand. Trace of fine white broken shell fragments, dolomite rhombohedrons. Radiolaria and Foraminifera rare, no Ostracoda.
150′2″-151′6″	15.2	Phosphatic sand, dark greenish-brown; 40 percent very fine subangular to subrounded clear quartz sand, 40 percent very fine-grained light-brown to black phosphate, 15 percent coarse-sand to fine-gravel-size particles of light-brown to dark-gray phosphate, 5 percent fine subangular clear quartz sand. Trace of fine to medium white to light-gray broken shell fragments, fine subrounded frosted quartz sand, dolomite rhombohedrons. Radiolaria and Foraminifera rare, no Ostracoda.
151′6″-152′9″	10.1	Phosphatic sandy limestone, light-gray, poorly indurated; 35 percent white poorly consolidated limestone matrix, 30 percent very fine to fine-grained light-brown to dark-gray phosphate, 15 percent coarse-sand to fine-gravel-size particles of dark-gray to black phosphate, 15 percent very fine to fine-grained subangular to subrounded clear quartz sand, 5 percent fine to medium white broken shell fragments. Radiolaria and Foraminifera common, no Ostracoda.
152′8″-153′6″	0.29	Sandy limestone, light-gray, well indurated; 60 percent well to poorly consolidated white limestone matrix, 25 percent fine subangular to subrounded clear quartz sand, 15 percent fine-grained dark-brown phosphate. Trace of fine-grained dark-green glauconite, coarse-grained dark-brown to black phosphate. Foraminifera common, no Ostracoda.

Pinetown quadrangle PI-16-GRL

Upper Miocene-Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
99′9″-99′11″	0.79	Fossiliferous limestone, light gray; 70 percent medium to coarse light-gray to white shell fragments; 20 percent dark-gray fine crystalline limestone matrix, 5 percent coarse to medium subrounded clear quartz sand, 5 percent coarse-grained rounded brown phosphate. Foraminifera rare, no Ostracoda.
99′11″-101′8″	1.95	Sand, medium greenish-gray; 85 percent fine angular to subrounded clear quartz sand, 10 percent light-gray clay, 5 percent fine to coarse-grained light-brown to black phosphate. White fine to medium broken shell fragments and aggregates of light-gray limestone and sand prominent. Foraminifera common, diatoms very rare, no Ostracoda.
101′8″-104′6″	4.07	Sand, medium greenish-gray; 75 percent fine to medium angular to subangular clear quartz sand, 15 percent fine to coarse-grained light-brown to black phosphate, 10 percent light-gray clay. White medium to coarse broken shell fragments and medium-gravel-size particles of dark-brown to black phosphate prominent. Trace of coarse subangular clear quartz sand. Foraminifera and Ostracoda common, no diatoms.
104′6″-106′4″	5.14	Sand, medium greenish-gray; same as 101′8″-104′6″ interval with 5 percent sand and corresponding decrease in fine quartz sand. Slight increase in phosphate pebbles. Foraminifera rare, no Ostracoda or diatoms.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
106′4″-107′4″	10.8	Phosphatic sand and clay, dark greenish-brown; 30 percent fine to medium subangular clear quartz sand, 30 percent fine to medium-grained light-brown to black phosphate, 20 percent very fine angular clear quartz sand, 20 percent greenish-brown clay. Trace of rose quartz. The interval 106′4″-106′8″ contains layers of medium-gray sand (same as 104′6″-106′4″ interval) interbedded with the phosphatic sand and clay. Foraminifera rare, no Ostracoda.
107′4″-108′4″	10.8	Phosphatic sand and clay, dark greenish-brown; 45 percent fine to medium light-brown to dark-brown phosphate, 35 percent fine angular to subangular clear quartz sand, 20 percent greenish-brown clay. Trace of amber, tan clay. No microfossils in slide but diatoms rare in washed sample.
108′4″-109′4″	16.2	Phosphatic sand, dark greenish-brown; 50 percent fine to medium-grained dark to light-brown phosphate, 30 percent fine subangular to subrounded clear quartz sand, 10 percent very fine angular clear quartz sand, 10 percent greenish-brown clay. Trace of medium broken shell fragments, fine-gravel-size particles of phosphate, tan clay. Foraminifera rare, no Ostracoda or diatoms.
109′4″-110′5″	16.2	Phosphatic sand, dark greenish-brown; same as 108′4″-109′4″ interval with no microfossils. The interval 110′1″-110′5″ contains dark-brown clay interbedded with the phosphatic sand.
110′5″-111′3″	0.19	Calcareous sand, light olive-green; 50 percent very fine angular light-gray quartz sand, 50 percent very

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		fine-grained light-gray limestone. No microfossils. The interval 110′5″-111′0″ contains layers of phosphatic sand interbedded with the calcareous sand.
111′3″-111′9″	0.19	Sandy limestone, medium greenish-gray, well indurated; 60 percent very fine-grained light-gray limestone, 40 percent very fine angular quartz sand. Trace of fine-grained dark-brown phosphate, medium angular clear quartz sand. No microfossils.
111′9″-112′9″	20.0	Phosphatic sand, dark greenish-brown; 65 percent fine angular to subrounded clear quartz sand, 35 percent fine-grained light to dark-brown phosphate. Trace of coarse-grained phosphate, fine-gravel-size aggregates of light-gray limestone and phosphate. No microfossils.
112′9″-113′5″	20.0	Phosphatic sand, dark greenish-brown; same as 111′9″-112′9″ interval.
113′5″-114′5″	19.1	Phosphatic sand, dark greenish-brown; same as 112′9″-113′5″ interval.
114′5″-115′2″	19.1	Phosphatic sand, dark greenish-brown; same as 113′5″-114′5″ interval with 10 percent increase in light-gray limestone and phosphate aggregates and corresponding decrease in quartz sand and phosphate. No microfossils.
115′2″-115′8″	5.89	Phosphatic sandy limestone, medium greenish-gray; 55 percent light-gray well indurated limestone matrix, 25 percent fine angular to subangular clear quartz sand, 20 percent fine-grained light to dark-brown phosphate. No mircrofossils.
115′8″-115′10″	6.02	Phosphatic sand and weathered limestone, dark greenish-brown to light-gray. This interval consists of alternating layers of phosphatic sand (same as 115′2″-115′8″ interval) and light-gray weathered limestone. No microfossils.
115′10″-116′5″	6.02	Phosphatic sandy limestone, light-gray; 65 percent light-gray very fine crystalline well indurated limestone matrix, 25 percent fine subrounded clear quartz sand, 10 percent fine-grained dark-brown to black phosphate. No microfossils.
116′5″-118′1″		No sample.
118′1″-118′10″	6.35	Phosphatic sandy limestone, light-greenish-gray, well indurated; same as 115′10″-116′5″ interval with 10 percent decrease in quartz sand and corresponding increase in limestone. No microfossils.
118′10″-119′6″	11.3	Phosphatic sand and clay, medium olive-green; 55 percent fine angular to subangular clear quartz sand, 25 percent light greenish-brown clay matrix, 20 percent fine-grained light to dark-brown phosphate. Very fine angular clear quartz sand prominent. Trace of fine-sand-size light-gray limestone aggregates, medium quartz gravel. No microfossils.
119′6″-120′6″	11.3	Phosphatic sand and clay, medium olive-green; same as 118′10″-119′6″ interval with 5 percent increase in fine-grained phosphate and corresponding decrease in fine quartz sand. No microfossils.
120′6″-121′4″	14.2	Phosphatic sand, dark greenish-gray; 65 percent fine to medium angular to subrounded clear quartz sand, 25 percent fine to medium-grained light-brown to black phosphate, 10 percent light-gray clay. Trace of limestone. No microfossils.
121′4″-122′9″	14.2	Phosphatic sand, dark greenish-gray; same as 120′6″-121′4″ interval.
122′9″-128′10″		No sample.
128′10″-137′2″	1.83	Phosphatic sandy limestone, medium greenish-gray; 80 percent very fine crystalline well indurated limestone, 10 percent fine subangular to subrounded clear quartz sand, 10 percent fine-grained dark-brown to black phosphate. No microfossils.
137′2″-138′2″	17.2	Phosphatic sand, dark greenish-brown; 70 percent fine to medium angular to subangular clear quartz sand, 30 percent fine to medium-grained light-brown to black phosphate. Fine-sand-size light-gray limestone aggregates prominent. No microfossils.
138′2″-139′2″	17.2	Phosphatic sand, dark greenish-brown; same as 137′2″-138′2″ interval.
139′2″-139′4″	1.83	Phosphatic sandy limestone, medium-gray; 55 percent very fine crystalline light-gray well indurated limestone matrix, 25 percent fine to medium angular to subangular clear quartz sand, 20 percent fine-grained light to dark-brown phosphate. Trace of coarse-grained dark-brown to black phosphate. No microfossils.
		Eocene—Castle Hayne Limestone
139′4″-143′7″	0.12	Shell limestone, light-gray, well indurated; 75 percent fossil casts and molds, 25 percent very fine-grained light-gray to white limestone matrix. Trace of fine subrounded clear quartz sand, fine-grained black phosphate. Foraminifera rare, no Ostracoda.
143′7″-147′7″	0.07	Shell limestone, light gray, well indurated; same as 139′4″-143′7″ interval.
147′7″-148′7″	0.07	Shell limestone, light-gray, well indurated; same as 143′7″-147′7″ interval with no microfossils.
148′7″-151′11″	0.07	Shell limestone, light-gray, well in-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		durated; same as 147′7″-148′7″ interval with Foraminifera rare, no Ostracoda.

Pinetown quadrangle PI-23-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
90′0″-92′10″	3.33	Sand, light-gray; 90 percent fine angular to subangular clear quartz sand, 10 percent fine to coarse-grained black phosphate. Trace of medium broken shell fragments, rose quartz. Foraminifera and Ostracoda common.
92′10″-94′10″	3.97	Sand and shell, gray-white, mottled; 60 percent fine subangular to subrounded clear quartz sand, 30 percent very coarse white shell fragments, 10 percent fine to coarse-grained black phosphate. Medium-gravel-size particles of phosphate prominent. Trace of rose quartz, smoky quartz. Foraminifera common, Ostracoda rare.
94′10″-95′10″	3.97	Sand and shell, gray-white, mottled; same as 92′10″-94′10″ interval with 10 percent increase in coarse broken shell fragments and corresponding decrease in fine quartz sand.
95′10″-96′5″	3.97	Sand and shell, gray-white, mottled; same as 94′10″-95′10″ interval with 10 percent increase in fine quartz sand and corresponding decrease in coarse broken shell fragments. Slight increase in fine-grained phosphate. Foraminifera rare, no Ostracoda.
96′5″-97′5″	6.30	Sand, medium greenish-gray; 70 percent fine angular to subangular clear quartz sand, 20 percent medium subangular to subrounded clear quartz sand, 10 percent fine-grained dark-brown to black phosphate. Fine-gravel-size phosphate prominent. Trace of fine to medium broken shell fragments, rose quartz. Foraminifera rare, no Ostracoda.
97′5″-98′5″	6.30	Sand, medium greenish-gray; same as 96′5″-97′5″ interval with trace of medium-gravel-size phosphate. No shell fragments. Foraminifera very rare, no Ostracoda.
98′5″-99′5″	6.30	Sand, medium greenish-gray; same as 97′5″-98′5″ interval.
99′5″-99′10″	6.30	Phosphatic sand, dark greenish-gray; 60 percent fine angular to subangular clear quartz sand, 20 percent medium subangular to subrounded clear quartz sand, 10 percent fine-grained light to dark-brown phosphate, 10 percent fine to medium-gravel-size dark-brown to black phosphate. Trace of rose quartz. Foraminifera very rare, no Ostracoda.
99′10″-100′11″	5.91	Phosphatic sand and clay, medium olive-green; 65 percent medium olive-green calcareous clay, 15 percent fine angular to subangular clear quartz sand, 10 percent medium subangular to subrounded clear quartz sand, 5 percent fine-grained light to dark-brown phosphate, 5 percent medium-gravel-size oolites of phosphate, with a fine-grained calcareous shell surrounding a core of very fine-grained phosphate. The nucleii of the oolites are medium subangular grains of phosphate. Trace of coarse-gravel-size black phosphate. Foraminifera very rare, no Ostracoda.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
100′11″-101′2″	5.91	Phosphatic sand, dark greenish-brown; 50 percent fine angular to subangular clear quartz sand, 40 percent fine-grained light to dark-brown phosphate, 10 percent medium subangular to subrounded clear quartz sand. Trace of very coarse-sand-size black phosphate. Diatoms rare, no Foraminifera or Ostracoda. The upper 1-inch of this interval contains calcareous clay, same as 99′10″-100′11″ interval.
101′2″-102′4″	18.7	Phosphatic sand, dark greenish-brown; same as 100′11″-101′2″ interval with no calcareous clay. Foraminifera very rare, no Ostracoda.
102′4″-103′4″	16.1	Phosphatic clay and sand, dark greenish-brown; 40 percent dark olive-green clay, 30 percent fine to medium subangular to subrounded clear quartz sand, 30 percent fine to medium-grained light to dark-brown phosphate. Trace of coarse-sand-size dark-brown phosphate. Ostracoda rare, no Foraminifera. Trace of coarse subrounded quartz sand.
103′4″-104′4″	16.1	Phosphatic sand and clay, medium greenish-brown; same as 102′4″-103′4″ interval with 10 percent decrease in clay and corresponding increase in fine quartz sand. No microfossils.
104′4″-104′10″	16.1	Phosphatic sand, dark greenish-brown; 45 percent light to dark-brown phosphate, 35 percent fine angular to subangular clear quartz sand, 10 percent medium subangular to subrounded clear quartz sand, 10 percent medium olive-green clay. Trace of coarse quartz sand, fine-gravel-size black phosphate. Slide shows one phosphoritized diatom, no Foraminifera or Ostracoda.
104′10″-105′10″	18.4	Phosphatic sand, dark greenish-brown; same as 104′4″-104′10″ interval with 10 percent decrease in clay and corresponding increase in fine quartz sand. No microfossils.
105′10″-106′10″	18.4	Phosphatic sand, dark greenish-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		brown; same as 104′10″-105′10″ interval.
106′10″-107′10″	12.3	Phosphatic sand and clay, medium olive-green; 40 percent fine to medium subangular to subrounded clear quartz sand, 35 percent fine-grained light to dark-brown phosphate, 30 percent light greenish-gray slightly calcareous clay. Trace of fine-gravel-size black phosphate. No microfossils.
107′10″-108′10″	12.3	Phosphatic sand and clay, medium olive-green; same as 106′10″-107′10″ interval.
108′10″-111′10″	12.3	Phosphatic sand and clay, medium olive-green; same as 107′10″-108′10″ interval with 5 percent increases in fine-grained phosphate and corresponding decrease in fine to medium quartz sand. No microfossils.
111′10″-112′10″	11.2	Phosphatic sand and clay, medium olive-green; same as 108′10″-111′10″ interval with trace of medium to coarse broken shell fragments. Foraminifera and Ostracoda rare.
112′10″-113′4″	11.2	Phosphatic sandy clay, medium olive-green; same as 111′10″-112′10″ interval with clay more calcareous. No shell fragments. No microfossils.
113′4″-113′8″	7.68	Phosphatic sandy limestone, light-gray, poorly indurated; 60 percent light-gray very fine crystalline limestone, 20 percent fine to medium subangular to subrounded clear quartz sand, 20 percent fine-grained light to dark-brown phosphate. Trace of fine-gravel-size particles of black phosphate. Foraminifera and Ostracoda rare.
113′8″-114′4″	9.51	Phosphatic clay and sand, light greenish-gray; 40 percent light-gray calcareous clay, 35 percent fine to medium subangular to subrounded clear quartz sand, 25 percent fine to medium-grained light-brown to black phosphate. Trace of fine-gravel-size particles of dark-gray to dark-brown phosphate. Foraminifera very rare, no Ostracoda.
114′4″-115′2″	16.4	Phosphatic clay and sand, light greenish-gray; same as 113′8″-114′4″ interval with 5 percent decrease in calcareous clay and corresponding increase in phosphate. The interval 114′11″-115′2″ is dark greenish-brown phosphatic sand (described immediately below). Foraminifera and Ostracoda rare.
115′2″-116′2″	18.5	Phosphatic sand, dark greenish-brown; 60 percent fine angular to subangular clear quartz sand, 30 percent fine to medium-grained light-tan to dark-brown phosphate, 10 percent medium subangular to subrounded clear quartz sand. Weathered light-tan phosphate prominent. Trace of fine-gravel-size dark-brown to black phosphate. No microfossils.
116′2″-116′8″	18.5	Phosphatic sand, dark greenish-brown; same as 115′2″-116′2″ interval. Foraminifera rare, no Ostracoda.
116′8″-120′1″	19.5	Phosphatic sand, dark greenish-brown; 65 percent fine angular to subangular clear quartz sand, 35 percent fine to medium-grained light-tan to dark-brown phosphate. Medium subangular to subrounded clear quartz sand and fine-gravel-size dark-gray to black phosphate prominent. No microfossils.
120′1″-121′1″	11.6	Phosphatic sand and clay, medium olive-green; thin layers (¼-inch average thickness) of phosphatic sand alternating with layers of dark-olive-green clay (½-¾-inch in thickness). Overall sample: 85 percent dark olive-green clay, 10 percent fine to medium subangular to subrounded clear quartz sand, 5 percent fine to medium-grained light-brown to black phosphate. Phosphatic sand layers: 60 percent sand, 20 percent phosphate, 20 percent clay. The clay layers contain about 6 percent each of sand and phosphate. No microfossils.
121′1″-122′1″	11.6	Phosphatic sand, dark greenish-brown; 55 percent very fine to fine angular to subangular clear quartz sand, 25 percent fine to medium-grained light-brown to black phosphate, 10 percent medium to coarse subangular to subrounded clear quartz sand, 10 percent fine to medium-gravel-size particles of dark-brown to black phosphate. Foraminifera very rare, no Ostracoda. The upper 3-inches of this interval contains layers of dark olive-green clay, same as 120′1″-121′1″ interval.
122′1″-122′10″	11.6	Phosphatic sandy clay, light olive-green; 55 percent light olive-green slightly calcareous clay, 30 percent fine to very fine angular to subangular clear quartz sand, 10 percent coarse-sand to medium-gravel-size particles of dark-brown to black phosphate, 5 percent fine-grained dark to light-brown phosphate. Trace of light-tan to light-gray weathered phosphate, light-gray limestone and phosphate aggregates. No microfossils.
122′10″-123′10″	5.73	Phosphatic sandy clay, light olive-green; same as 122′1″-122′10″ interval with slight increase in coarse phosphate. No microfossils.
123′10″-124′10″	5.73	Sandy clay, light olive-green; 60 percent light olive-green slightly calcareous clay, 30 percent very fine angular light-gray quartz sand, 10 percent coarse-sand to medium-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		gravel-size particles of dark-brown to black phosphate. Trace of coarse subrounded clear quartz sand. No microfossils.
124′10″-125′7″	5.73	Sandy clay, light olive-green; same as 123′10″-124′10″ interval with 10 percent decrease in coarse phosphate and corresponding increase in very fine quartz sand. Trace of phosphate, light-gray limestone aggregates. No microfossils.
125′7″-125′11″	1.86	Limestone, light-gray. Well indurated very fine crystalline limestone. Trace of very fine-grained light to dark-brown phosphate, fine subangular clear quartz sand. No microfossils.
125′11″-127′11″		No sample.
127′11″-129′2″	2.52	Sandy limestone, light greenish-gray; 60 percent very fine light-gray crystalline limestone, 30 percent very fine light-gray quartz sand, 10 percent very fine-grained light to dark-brown phosphate. Well indurated. No microfossils.

Pungo Lake quadrangle PL-1-GRL

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
204′0″-205′0″	3.49	Shell limestone, dark-gray, well indurated; 50 percent dark gray-brown very fine crystalline limestone matrix, 25 percent fossil casts and molds, replaced by dark gray-brown limestone, 15 percent very fine to medium-grained dark-brown phosphate, 10 percent very fine to fine subrounded clear to frosted quartz sand. Foraminifera very rare, no Ostracoda.
205′0″-211-0″	3.49	Sandy shell limestone, medium-gray, well indurated; 40 percent medium-gray very fine crystalline limestone matrix, 25 percent fine to medium subangular to subrounded clear to frosted quartz sand, 20 percent fossil casts and molds, replaced by medium-gray limestone, 15 percent fine-grained light to dark-brown phosphate. Foraminifera very rare, no Ostracoda.
211′0″-216′0″	6.44	Phosphatic sandy limestone, dark greenish-brown, poorly indurated; 55 percent dark gray-brown very fine crystalline limestone, 25 percent fine to medium subangular to subrounded clear to frosted quartz sand, 20 percent fine to medium-grained light to dark-brown phosphate. Trace of smoky quartz. Foraminifera common, no Ostracoda.
216′0″-223′0″		No sample.
223′0″-225′0″	7.12	Phosphatic sand, dark greenish-brown; 60 percent very fine to fine subangular to subrounded clear quartz sand, 30 percent very fine to fine-grained black to dark-brown phosphate, 10 percent medium greenish-gray clay. Trace of medium subangular to subrounded clear to frosted quartz sand, coarse-sand to fine-gravel-size particles of dark-brown to black phosphate. Foraminifera rare, no Ostracoda.
225′0″-227′4″	6.04	Phosphatic sand, dark greenish-brown; same as 223′0″-225′0″ interval with 10 percent increase in fine-grained phosphate and corresponding decrease in fine quartz sand. No coarse-grained phosphate. Foraminifera and radiolaria rare, no Ostracoda.
227′4″-229′4″	7.06	Phosphatic sand, dark greenish-brown; same as 225′0″-227′4″ interval with no microfossils.
229′4″-231′4″	8.57	Clay, medium olive-green; 85 percent medium olive-green calcareous clay, 10 percent very fine to fine subangular to subrounded clear quartz sand, 5 percent very fine-grained light-brown to black phosphate. Trace of fine-grained limestone, medium subrounded clear to frosted quartz sand, medium-grained light to dark-brown phosphate, calcite and dolomite rhombohedrons. Foraminifera and radiolaria common, no Ostracoda.
231′4″-233′0″	8.57	Clay, medium olive-green; same as 229′4″-231′4″ interval.
233′0″-234′0″		No sample.
234′0″-235′0″	5.40	Clay, medium olive-green; 75 percent medium olive-green calcareous clay, 10 percent very fine to fine-grained light-brown to black phosphate, 10 percent fine angular to subangular clear quartz sand, 5 percent medium subangular to subrounded clear quartz sand. Medium-grained dark-brown to dark-gray phosphate and coarse-sand to medium-gravel-size aggregates of light-gray limestone and phosphate prominent. Trace of fine white broken shell fragments. Foraminifera abundant, radiolaria common, no Ostracoda.
235′0″-237′0″	5.40	Clay, medium olive-green; same as 234′0″-235′0″ interval.
237′0″-239′6″	5.40	Clay, medium olive-green; same as 235′0″-237′0″ interval with Foraminifera and radiolaria rare, no Ostracoda.
239′6″-241′0″	10.9	Sand and clay, light greenish-gray; 50 percent fine angular to subangular frosted to clear quartz sand, 25 percent light greenish-gray calcareous clay, 15 percent coarse-sand to fine-gravel-size particles of dark-brown to black phosphate, 5 percent fine white broken shell fragments, 5 percent fine quartz sand with lime coating. Fine-grained bright-green glauconite, fine-grained dark-brown phosphate prominent. Trace of fine to medium-size aggregates of dark-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		gray limestone and phosphate. Foraminifera common, no radiolaria or Ostracoda.

Pike Road quadrangle PR-1-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
175′0″-176′6″	5.53	Phosphatic sand, clay and shell, gray-white mottled; 35 percent fine to medium subangular to subrounded clear quartz sand, 25 percent fine to coarse light-gray to white broken shell fragments, 20 percent fine to medium-grained dark-brown phosphate, 20 percent medium greenish-gray clay. Trace of medium subrounded frosted quartz sand. Foraminifera very abundant, Ostracoda and radiolaria rare.
176′6″-178′2″	5.53	Phosphatic sand, clay and shell, gray-white mottled; same as 175′0″-176′6″ interval with 15 percent increase in phosphate and corresponding decrease in fine to medium quartz sand. The lower 0.3 foot of this interval is very rich in phosphate and sand. For entire interval: Foraminifera and Ostracoda rare, no radiolaria.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
178′2″-180′0″	17.1	Phosphatic sand, dark greenish-brown; 50 percent very fine to fine-grained light to dark-brown phosphate, 40 percent fine to medium angular to subangular clear quartz sand, 10 percent coarse subangular to subrounded clear quartz sand. Dark-gray clay prominent. Trace of coarse-grained dark-brown to dark-gray phosphate. Foraminifera very rare, no Ostracoda.
180′0″-181′6″	17.1	Phosphatic sand, dark greenish-brown; same as 178′2″180′0″ foot interval with 10 percent increase in phosphate and corresponding decrease in coarse quartz sand. Trace of fine subrounded frosted quartz sand. No microfossils. Trace of fossil vertebrae.
181′6″-187′0″		No sample.
187′0″-189′0″	9.73	Phosphatic limestone, medium-gray, well indurated; 60 percent medium-gray very fine crystalline limestone matrix, 30 percent very fine to fine-grained dark-brown phosphate, 10 percent very fine to fine subrounded clear to frosted quartz sand. No microfossils.
189′0″-194′0″	5.90	Phosphatic sandy limestone, medium-gray, well indurated; 40 percent medium-gray very fine crystalline limestone matrix, 30 percent very fine-grained dark-brown to black phosphate, 30 percent very fine to fine subangular to subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.
194′0″-195′5″	11.3	Phosphatic sand and clay, light greenish-gray; 50 percent very fine to fine angular to subangular clear quartz sand, 20 percent light greenish-gray slightly calcareous clay, 20 percent very fine to fine-grained light to dark-brown phosphate, 10 percent light-brown to white fine-grained phosphate with lime covering grains. Trace of dark-brown limestone and phosphate aggregates, medium subrounded clear quartz sand. Foraminifera rare, no Ostracoda.
195′5″-197′1″	12.3	Phosphatic sand, dark greenish-brown; 70 percent very fine to fine subangular to subrounded clear quartz sand, 20 percent very fine to fine-grained light to dark-brown phosphate, 10 percent fine-grained light-brown phosphate with lime coating grains. Trace of medium subrounded clear quartz sand, black clay. Foraminifera rare, no Ostracoda.
197′1″-198′1″	11.4	Phosphatic sand, dark greenish-brown; same as 195′5″-197′1″ interval with no microfossils.
198′1″-199′5″	11.4	Phosphatic sand, dark greenish-brown; same as 197′1″-198′1″ interval with radiolaria and sponge spicules rare.
199′5″-200′3″	10.2	Phosphatic sand and clay, dark greenish-brown; 55 percent fine subangular to subrounded clear quartz sand, 25 percent dark-gray clay, 20 percent fine to medium-grained light-gray to light-brown phosphate. Medium subangular to subrounded clear to frosted quartz sand prominent. Foraminifera rare, no radiolaria, sponge spicules, or Ostracoda.
200′3″-202′1″	10.5	Phosphatic sand, dark greenish-brown; 75 percent very fine to fine angular to subangular clear quartz sand, 15 percent fine-grained dark-gray to light-brown phosphate, 10 percent fine-grained light-gray to white phosphate with lime coating. Trace of medium subangular clear quartz sand, medium-grained dark-gray phosphate, very fine-grained bright-green glauconite. Radiolaria and diatoms rare, no Foraminifera or Ostracoda.
202′1″-203′9″	11.5	Sand, medium greenish-gray; 80 percent fine subangular to subrounded clear quartz sand, 10 percent light-gray clay, 5 percent fine-grained light-gray to light-brown phosphate. 5 percent fine-grained light-brown phosphate with lime coating. Trace of medium subangular to subrounded clear quartz sand, medium-grained dark-gray to dark-brown phosphate. Radiolaria common, no diatoms, Foraminifera or Ostracoda.
203′9″-204′4″	10.1	Sand, medium greenish-gray; 55 percent fine angular to subangular

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		clear quartz sand, 20 percent medium subangular to subrounded clear to frosted quartz sand, 10 percent fine to medium-grained light-gray to light-brown phosphate, 10 percent light-gray clay, 5 percent fine-grained light-brown phosphate with lime coating. Trace of coarse-sand to fine-gravel-size particles of dark-brown to dark-gray phosphate. Radiolaria common, diatoms rare, no Foraminifera or Ostracoda.
204′4″-205′5″	10.5	Sand, medium greenish-gray; same as 203′9″-204′4″ interval with 10 percent increase in fine quartz sand and corresponding decrease in medium quartz sand. Radiolaria and diatoms rare, no Foraminifera or Ostracoda.
205′5″-206′5″	5.58	Sand, dark greenish-brown; 75 percent very fine angular to subangular clear quartz sand, 10 percent dark olive-green clay, 10 percent very fine-grained light to dark-brown phosphate, 5 percent medium subangular to subrounded clear quartz sand. Trace of coarse-sand to fine-gravel-size particles of dark-gray to black phosphate, very fine-grained bright-green glauconite. Foraminifera rare, no radiolaria, diatoms or Ostracoda.
206′5″-207′5″	5.58	Sand, dark greenish-brown; same as as 205′5″-206′5″ interval.
207′5″-208′5″	5.62	Sand, dark greenish-brown; same as 206′5″-207′5″ interval with no microfossils. The lower 2 inches of this interval is calcareous clay and sand, same as 208′5″-209′7″ interval.
208′5″-209′7″	3.23	Calcareous clay and sand, medium olive-green; this interval is chiefly calcareous clay but contains minor layers of sand and clay. For entire interval: 70 percent medium olive-green highly calcareous clay, 20 percent fine subangular to subrounded clear quartz sand, 5 percent very fine to fine-grained light-gray to light-brown phosphate. Trace of medium subangular to subrounded clear to frosted quartz sand, coarse-sand to medium-gravel-size particles of dark-gray to black phosphate, calcite and dolomite rhombohedrons. Foraminifera rare, no Ostracoda.
209′7″-212′8″		No sample.
212′8″-214′8″	3.61	Calcareous clay, medium olive-green; 80 percent medium olive-green highly calcareous clay, 10 percent very fine to fine subangular to subrounded clear to frosted quartz sand, 5 percent very fine to medium-grained light-brown to black phosphate, 5 percent very fine-sand-size particles of white limestone. Coarse-sand-size particles of dark-gray to black phosphate prominent. Trace of fine white broken shell fragments. Foraminifera very abundant, radiolaria rare, no Ostracoda.
214′8″-216′11″	3.62	Calcareous clay, medium olive-green; same as 212′8″-214′8″ interval.
216′11″-217′6″	9.48	Phosphatic sand and clay, medium greenish-gray; 50 percent fine subangular to subrounded clear quartz sand, 25 percent medium olive-green highly calcareous clay, 20 percent coarse-sand to fine-gravel-size particles of dark-brown to black phosphate, 5 percent medium subrounded clear to frosted quartz sand. Very fine-grained dark-brown phosphate, coarse-sand-size aggregates of dark-gray limestone prominent. Trace of rose quartz. Foraminifera very abundant, no radiolaria or Ostracoda.

Pike Road quadrangle PR-2-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
150.0-153.0	0.04	Clay, light greenish-gray; 90 percent light-green calcareous clay, 5 percent fine subrounded clear to frosted quartz sand, 5 percent fine to very coarse light-gray to white shell fragments. Medium to coarse subrounded clear to frosted quartz sand prominent. Small *Turritella* common. Trace of fine-grained muscovite. Foraminifera abundant, Ostracoda rare.
153.0-156.0	0.02	Clay, light greenish-gray; same as 150.0-153.0 foot interval with decrease in quartz sand to only a trace and corresponding increase in clay. Biotite and muscovite prominent. Foraminifera abundant, Ostracoda rare.
156.0-159.5	0.22	Clay, light greenish-gray; same as 153.0-156.0 foot interval. The lower 0.3 foot of this interval contains 10 percent very fine subangular to subrounded clear quartz sand.
159.5-173.0		No sample.
173.0-175.5	0.08	Clay, light greenish-gray; 85 percent light greenish-gray calcareous clay, 15 percent very fine to medium broken shell fragments. Very fine subrounded clear to frosted quartz sand, fine-grained biotite and muscovite, medium-grained pyrite aggregates prominent. Foraminifera abundant, Ostracoda rare.
175.5-177.0	1.29	Clay and sand, gray-white mottled; 45 percent light greenish-gray calcareous clay, 35 percent fine to medium subangular to subrounded clear quartz sand, 15 percent fine to medium light-gray to white

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		broken shell fragments, 5 percent fine to medium-grained dark-brown to black phosphate. Fine to medium-grained light to dark-green glauconite prominent. Trace of *Turritella* fragments. Foraminifera very abundant, no Ostracoda.
177.0-178.5	3.84	Clay, sand and shell, gray-white mottled; 40 percent light-gray highly calcareous clay, 30 percent medium to coarse subangular to subrounded clear quartz sand, 20 percent fine to medium light-gray to white broken shell fragments, 10 percent fine to coarse-grained dark-brown to black phosphate. Limestone and glauconite aggregates prominent. The lower 0.4 foot of this interval contains slightly more shell, while the clay is white and highly calcareous. For entire interval: Foraminifera common, no Ostracoda.
		Middle Miocene—Pungo River Formation
178.5-202.0		No sample.
202.0-204.0	2.88	Sand and clay, medium olive-green; 55 percent fine subangular to subrounded clear quartz sand, 35 percent medium olive-green clay, 10 percent very fine to fine dark-brown to black phosphate. Trace of medium subrounded clear quartz sand, coarse-grained dark-brown to black phosphate. Foraminifera common, no Ostracoda.
204.0-205.5	1.98	Clay and sand, medium olive-green; 60 percent medium olive-green clay, 30 percent fine subangular to subrounded clear quartz sand, 10 percent fine to medium light-gray to white broken shell fragments. Fine to medium-grained dark-brown to black phosphate prominent. Trace of medium subrounded clear to frosted quartz sand, fossil vertebrae. Foraminifera rare, no Ostracoda.
205.5-207.0	1.06	Clay, dark olive-green; 90 percent dark olive-green clay, 10 percent fine to medium subangular to subrounded clear quartz sand. Fine to medium-grained dark-brown to black phosphate prominent. Foraminifera very rare, no Ostracoda.
207.0-209.0	0.70	Clay, dark olive-green; same as 205.5-207.0 foot interval with diatoms and Foraminifera rare, no Ostracoda.
209.0-211.0	0.08	Clay, dark olive-green; same as 207.0-209.0 foot interval with quartz grains commonly frosted. Trace of medium white broken shell fragments. Foraminifera and radiolaria common, no Ostracoda.
211.0-213.0	1.92	Clay, medium olive-green; 90 percent medium olive-green slightly calcareous clay, 10 percent fine subangular to subrounded clear quartz sand. Fine-grained light-brown to black phosphate, fine light-gray to white broken shell fragments, frosted quartz sand prominent. Trace of medium subrounded frosted quartz sand. Foraminifera and radiolaria common, no Ostracoda.
213.0-214.5	1.92	Clay, medium olive-green; 90 percent medium olive-green clay, 5 percent very fine to fine subangular to subrounded clear quartz sand, 5 percent very fine to fine-grained dark-brown to black phosphate. Trace of rose quartz, fine light-gray to white broken shell fragments, light-brown clay, black clay. Foraminifera and radiolaria rare, no Ostracoda. The lower 0.2 foot of this interval is phosphatic sand, same as 214.5-215.0 foot interval.
214.5-215.0	14.5	Phosphatic sand and clay, dark greenish-brown; 35 percent very fine subangular to subrounded clear quartz sand, 25 percent very fine to fine-grained light-brown to black phosphate, 20 percent medium olive-green clay, 20 percent coarse-sand to fine-gravel-size particles of dark-brown to dark-gray phosphate. Trace of light-gray limestone and phosphate aggregates, medium white broken shell fragments, very fine-grained bright-green glauconite. Foraminifera common, radiolaria rare, no Ostracoda.
		Eocene—Castle Hayne Limestone
215.0-215.5	1.47	Sandy limestone, dark-gray, well indurated; 65 percent dark-gray fine crystalline limestone matrix, 20 percent very fine subangular to subrounded clear quartz sand, 15 percent very fine-grained dark to light-green glauconite. Trace of medium-grained light-brown to light-gray phosphate. Foraminifera rare, no Ostracoda.
215.5-226.0		No sample.
226.0-227.0	0.14	Sandy limestone, light-gray; 70 percent white to light-gray poorly indurated limestone matrix, 20 percent very fine subangular to subrounded clear quartz sand, 10 percent very fine-grained dark-green glauconite. Fossil casts and molds very prominent. Foraminifera very rare, no Ostracoda.
227.0-228.5	0.14	Sandy limestone, light-gray; same as 226.0-227.0 foot interval with 10 percent increase in quartz sand and corresponding decrease in limestone. The lower 0.2 foot of this interval is well indurated and contains very large fossil casts and molds. For entire interval: Foraminifera rare, no Ostracoda.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
150.0-152.4	12.9	Phosphatic sandy limestone, poorly indurated, medium greenish-gray, alternating with layers of phosphatic sand, dark greenish-brown; limestone very prominent in upper 1 foot of interval, phosphatic sand more prominent in lower 1.4 feet. Composition of limestone: 40 percent fine-grained dark-brown to black phosphate, 30 percent fine to medium subangular to subrounded clear quartz sand, 30 percent poorly indurated white limestone matrix. Trace of fine-grained dark-green glauconite. Composition of phosphatic sand: 35 percent very fine to fine-grained subangular clear quartz sand, 35 percent very fine to fine-grained dark-brown to black phosphate, 25 percent medium-sand-size particles of light-gray limestone, 5 percent medium subangular to subrounded clear to frosted quartz sand. Trace of fine-grained dark-green glauconite. For entire interval: Foraminifera common, no Ostracoda.
152.4-154.0	16.0	Phosphatic sand, dark greenish-brown; 40 percent fine angular to subangular clear quartz sand, 30 percent fine-grained light to dark-brown phosphate, 25 percent fine-grained phosphate coated with light-gray limestone, 5 percent medium subangular to subrounded clear to frosted quartz sand. Trace of medium-grained dark-brown to dark-gray phosphate. Foraminifera common, no Ostracoda. Fossil vertebrae present.
154.0-155.4	14.0	Phosphatic sand, dark greenish-brown; same as 152.4-154.0 foot interval with Foraminifera rare, no Ostracoda.
155.4-157.5	14.0	Phosphatic sand, dark greenish-brown; same as 154.0-155.4 foot interval with radiolaria common, diatoms rare, no Foraminifera or Ostracoda.
157.5-159.5	12.9	Phosphatic sand, dark greenish-brown; same as 155.4-157.5 foot interval with 10 percent decrease in lime-coated phosphate and corresponding increase in fine quartz sand. Radiolaria common, Foraminifera very rare, no Ostracoda.
159.5-160.0	8.01	Phosphatic sand, dark greenish-brown; 55 percent fine angular to subangular clear quartz sand, 35 percent fine to medium-grained light to dark-brown phosphate, 10 percent medium subangular to subrounded clear to frosted quartz sand. Fine-gravel-size particles of dark-brown to black phosphate prominent. Radiolaria and fossil vertebrae rare, no Foraminifera or Ostracoda.
160.0-161.5	8.71	Phosphatic sand, dark greenish-brown; 55 percent very fine angular to subangular clear quartz sand, 25 percent very fine-grained light to dark-brown phosphate, 10 percent fine subangular clear quartz sand, 10 percent coarse-sand to fine-gravel-size particles of dark-brown to black phosphate. Trace of light-brown limestone and phosphate aggregates, fine frosted quartz sand, very fine-grained bright-green glauconite. Foraminifera common, radiolaria and fossil vertebrae rare, no Ostracoda.
161.5-163.2	8.71	Phosphatic sand and clay, dark greenish-brown. The lower 0.4 foot of this interval is dark olive-green clay and sand, same as 163.2-164.5 foot interval. 45 percent fine angular to subangular clear quartz sand, 20 percent very fine to fine dark-brown to black phosphate, 20 percent medium olive-green clay, 15 percent coarse-sand to fine-gravel-size particles of dark-brown to black phosphate. Trace of fine frosted quartz sand, aggregates of light-brown limestone and phosphate. Foraminifera and diatoms rare, no Ostracoda.
163.2-164.5	5.74	Clay and phosphatic sand, dark olive-green; this interval consists of interbedded medium olive-green clay and dark greenish-brown phosphatic sand. For entire interval: 50 percent medium olive-green slightly calcareous clay, 30 percent very fine to fine angular to subangular clear quartz sand, 20 percent very fine to fine-grained light to dark-brown phosphate. Trace of fine subrounded frosted quartz sand, coarse-sand-size particles of dark-brown to black phosphate. Foraminifera common, no Ostracoda.
164.5-165.5	5.74	Clay and phosphatic sand, dark olive-green; same as 163.2-164.5 foot interval with 10 percent increase in very fine-grained phosphate, and corresponding decrease in clear quartz sand. Foraminifera common, no Ostracoda. The lower 0.2 foot of this interval is sand and clay, same as 165.5-166.5 foot interval.

Eocene—Castle Hayne Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
165.5-166.5	5.18	Sand and clay, medium greenish-gray; 50 percent fine subangular to subrounded clear quartz sand, 20 percent medium subrounded clear quartz sand, 15 percent medium olive-green clay, 10 percent very fine to fine-grained light to dark-brown phosphate, 5 percent coarse-sand to fine-gravel-size particles of dark-brown to black phosphate. Trace of medium subrounded frosted quartz sand, rose quartz. Foraminifera rare, no Ostracoda.
166.5-167.7	5.18	Sand and clay, medium greenish-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		gray; same as 165.5-166.5 foot interval with no microfossils.
167.7-168.7	2.79	Clay and sand, medium olive-green; this interval consists of medium olive-green clay with scattered thin layers of sand. For entire interval: 65 percent medium olive-green calcareous clay, 20 percent very fine to fine angular to subangular clear quartz sand, 5 percent medium subangular to subrounded clear to frosted quartz sand, 5 percent very fine-grained dark-brown to black phosphate, 5 percent coarse-sand to medium-gravel-size particles of dark-gray to black phosphate. Foraminifera rare, no Ostracoda.
168.7-170.0	2.79	Clay and sand, medium olive-green; same as 167.7-168.7 foot interval with radiolaria rare. Trace of calcite rhombohedrons.
170.0-170.5	1.57	Sandy limestone, medium-gray, well indurated; 65 percent medium-gray fine crystalline limestone matrix, 20 percent fine to medium subangular to subrounded clear to frosted quartz sand, 10 percent fine to medium light-gray to white broken shell fragments, 5 percent fine to medium-grained dark-brown phosphate. Foraminifera abundant, no Ostracoda.
170.5-172.0	3.12	Sand and limestone, white to light-gray, poorly indurated; 40 percent very fine to medium subangular to subrounded clear quartz sand, 30 percent chalk-white weathered limestone matrix, 20 percent coarse-sand to medium-gravel-size angular aggregates of light-gray limestone and very fine-grained phosphate, 10 percent fine to coarse white broken shell fragments. Foraminifera very rare, no Ostracoda.
172.0-198.0		No sample.
198.0-199.0	0.15	Sandy limestone, white to light-gray, poorly indurated; 80 percent microcrystalline white to light-gray limestone matrix, chiefly in the form of fossil fragments, casts and molds, 20 percent fine subangular to subrounded clear quartz sand. Fine-grained dark-green glauconite very prominent. This interval appears to be a cemented coquina. Foraminifera rare, no Ostracoda.
199.0-201.0	0.02	Sandy limestone, white to light-gray, poorly indurated. The upper 0.3 foot of this interval is cemented coquina, same as 198.0-199.0 foot interval. The lower 0.5 foot contains thin layers of very light-green highly calcareous clay. For entire interval: 60 percent light-gray to white limestone, weathered in part, 40 percent fine subangular to subrounded clear quartz sand. Fine-grained dark-green glauconite very prominent. Foraminifera and Ostracoda very rare.

Ransomville quadrangle RA-13-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
140′11″-141′11″	4.01	Sand, shell and clay, gray-white mottled; 50 percent fine to medium angular to subangular clear quartz sand, 20 percent dark-gray clay, 20 percent coarse soft white shell fragments, 10 percent fine to medium-grained dark-brown to black phosphate. Fine-gravel-size particles of dark-brown to black phosphate prominent.
141′11″-142′9″	4.01	Sand and clay, gray-white mottled; same as 140′11″-141′11″ interval with 5 percent decrease in shell fragments and corresponding increase in fine to medium quartz sand. Trace of rose quartz, coarse subrounded clear quartz sand. Foraminifera common, no Ostracoda.
142′9″-143′9″	4.93	Sand and clay, gray-white mottled; same as 141′11″-142′9″ interval.
143′9″-144′5″	4.93	Sand and clay, gray-white mottled; same as 142′9″-143′9″ interval with 5 percent increase in phosphate and corresponding decrease in dark-gray clay. Foraminifera common, no Ostracoda.
144′5″-145′0″	5.51	Sand, medium greenish-gray; 75 percent fine subangular to subrounded clear quartz sand, 15 percent light greenish-gray clay, 10 percent fine to medium-grained dark-brown to black phosphate. Fine-gravel-size particles of dark-brown to black phosphate and medium subangular clear quartz sand prominent. Trace of rose quartz. Foraminifera common, no Ostracoda.
145′0″-146′0″	5.51	Sand, medium greenish-gray; same as 144′5″-145′0″ interval.
146′0″-146′9″	5.51	Sand, medium greenish-gray; same as 145′0″-146′0″ interval with Foraminifera very rare, no Ostracoda. Trace of very fine-grained dark to bright-green glauconite.
146′9″-148′9″	5.65	Sand, medium greenish-gray; 65 percent fine subangular to subrounded clear quartz sand, 10 percent medium subangular to subrounded clear quartz sand, 10 percent fine to medium-grained dark-brown to black phosphate, 10 percent medium greenish-gray clay. Trace of fine subrounded clear quartz gravel. Trace of very fine-grained dark to light-green glauconite. Foraminifera very rare, no Ostracoda.
148′9″-149′9″	5.65	Sand, medium greenish-gray; same as 146′9″-148′9″ interval with no microfossils.
149′9″-150′3″	5.65	Sand, medium greenish-gray; same as 148′9″-149′9″ interval with Foraminifera very rare, no Ostracoda.
150′3″-150′8″		No sample.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
150′8″-151′8″	6.66	Sand and clay, dark greenish-brown; 40 percent fine subangular to subrounded clear quartz sand, 30 percent medium to coarse subangular to subrounded clear quartz sand, 20 percent dark greenish-gray clay, 10 percent fine to medium-grained dark-brown to black phosphate. Trace of very fine-grained bright-green glauconite. No microfossils.
151′8″-152′8″	6.44	Sand and clay, dark greenish-brown; same as 150′8″-151′8″ interval with 10 percent decrease in medium to coarse quartz sand and corresponding increase in fine quartz sand. Slight increase in fine-grained phosphate. No microfossils.
152′8″-153′8″	6.44	Sand and clay, dark greenish-brown; same as 151′8″-152′8″ interval.
153′8″-154′8″	6.44	Sand and clay, dark greenish-brown; same as 152′8″-153′8″ interval with trace of amber. No microfossils.
154′8″-157′1″	5.23	Sand and clay, medium greenish-brown; 75 percent very fine to fine angular to subangular clear quartz sand, 20 percent medium greenish-gray, 5 percent very fine to fine-grained dark-brown to black phosphate. Coarse subrounded clear quartz sand prominent. Trace of coarse-grained dark-brown to black phosphate, rose quartz, coarse subrounded clear to smoky quartz sand, very fine-grained bright-green glauconite. No microfossils.
157′1″-158′1″	5.23	Sand and clay, medium greenish-brown; same as 157′1″-158′1″ interval with small Foraminifera very rare, no Ostracoda.
158′1″-159′1″	5.23	Sand and clay, medium greenish-brown; Same as 157′1″-158′1″ interval.
159′1″-159′7″	5.23	Clay and sand, medium greenish-brown; 60 percent dark greenish-gray clay, 30 percent very fine to fine angular to subangular clear quartz sand, 10 percent fine to medium-grained dark-brown to black phosphate. Coarse sand size particles of phosphate and coarse subrounded to rounded quartz sand prominent. Trace of rose quartz, very fine-grained bright-green glauconite. Foraminifera rare, no Ostracoda.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
159′7″-160′7″	1.39	Clay, dark olive-green; 85 percent dark olive-green clay, 10 percent very fine to fine angular to subangular clear quartz sand, 5 percent fine to medium-grained light-brown to black phosphate. Medium subrounded quartz sand prominent. Trace of hematite-stained quartz. Foraminifera rare, no Ostracoda.
160′7″-161′7″	1.39	Clay, dark olive-green; same as 159′7″-160′7″ interval with Foraminifera and diatoms rare, no Ostracoda.
161′7″-162′7″	1.39	Clay, medium olive-green; dark-gray to light olive-green clay. Trace of medium subrounded quartz sand, fine-grained black phosphate. Diatoms and sponge spicules abundant, Foraminifera rare, no Ostracoda.
162′7″-163′8″	1.66	Clay, medium olive-green to greenish-white. Very light-weight, medium olive-green clay with a few scattered streaks and layers of greenish-white clay. Diatoms and fine to medium-grained light-brown to black phosphate prominent. Sponge spicules common, no Foraminifera or Ostracoda.
163′8″-164′8″	1.66	Clay, medium olive-green; same as 162′7″-163′8″ interval with no phosphate. Trace of coarse subrounded quartz sand. Diatoms very abundant, sponge spicules rare, no Foraminifera or Ostracoda.
164′8″-166′2″	0.59	Clay, medium olive-green; same as 163′8″-164′8″ interval.
166′2″-168′0″	1.19	Clay, medium olive-green; 85 percent very light-weight, light greenish-gray clay, 10 percent black clay, 5 percent very fine to fine-grained dark-brown to black phosphate. Trace of very fine angular quartz sand. Diatoms abundant, sponge spicules common, no Foraminifera or Ostracoda.
168′0″-169′2″	1.19	Clay, dark olive-green; 95 percent light-weight medium greenish-gray clay, 5 percent very fine to fine-grained dark-brown to black phosphate. Black clay prominent. Diatoms and sponge spicules common, no Foraminifera or Ostracoda.
169′2″-170′2″	1.46	Clay, dark olive-green; 85 percent light-weight medium greenish-gray clay, 10 percent black clay, 5 percent very fine to fine-grained dark-brown to black phosphate. Diatoms and sponge spicules abundant, no Foraminifera or Ostracoda.
170′2″-171′2″	1.46	Clay, dark olive-green; same as 169′2″-170′2″ interval.
171′2″-172′6″	1.46	Clay, dark olive-green; same as 170′2″-171′2″ interval with 5 percent decrease in black clay and corresponding increase in greenish-gray clay. Diatoms and sponge spicules common, no Foraminifera or Ostracoda.
172′6″-173′6″	9.38	Clay, dark olive-green; 85 percent very light-weight, light greenish-gray clay, 15 percent fine to coarse-sand-size particles of dark-brown to black phosphate. Fine to medium-gravel-size particles of dark-brown to black phosphate prominent. Trace of medium subangular to subrounded clear quartz sand. Diatoms common, sponge spicules rare, no Foraminifera or Ostracoda.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
173′6″-174′7″	9.38	Phosphatic clay, dark olive-green; same as 172′6″-173′6″ interval with 5 percent increase in fine to medium-gravel-size phosphate and corresponding decrease in greenish-gray clay. Trace of medium broken shell fragments. Diatoms abundant, sponge spicules and Foraminifera common, no Ostracoda.
174′7″-175′8″	0.95	Diatomaceous clay, light olive-green; 85 percent light olive-green very light-weight clay. Diatoms compose 15 percent of sample. Trace of medium subrounded clear quartz sand, reddish-brown phosphate. Sponge spicules common, Foraminifera rare, no Ostracoda.
175′8″-176′8″	0.95	Diatomaceous clay, light olive-green; same as 174′7″-175′8″ interval with no Foraminifera. Sponge spicules rare, no Ostracoda.
176′8″-177′9″	0.95	Diatomaceous clay, light olive-green; same as 175′8″-176′8″ interval.
177′9″-178′9″	2.77	Diatomaceous clay, light olive-green; same as 176′8″-177′9″ interval.
178′9″-180′1″	2.77	Diatomaceous clay, light olive-green; same as 177′9″-178′9″ interval. The interval 179′5″-179′7″ consists of phosphatic sandy clay, lithology as follows: 50 percent light olive-green very light-weight diatomaceous clay, 30 percent fine to medium subangular to subrounded clear quartz sand, 20 percent fine to medium-grained dark-brown to black phosphate. Diatoms abundant. For entire interval: Diatoms very abundant, sponge spicules rare, no Foraminifera or Ostracoda.
180′1″-181′1″	0.89	Diatomaceous clay, light olive-green; 85 percent light olive-green, very light-weight clay. Fine-grained dark-brown to black phosphate prominent. Diatoms compose 15 percent of sample. Trace of fine subrounded clear to smoky quartz sand. Sponge spicules rare, no Foraminifera or Ostracoda.
181′1″-182′1″	0.89	Diatomaceous clay, light olive-green; same as 180′1″-181′1″ interval with trace of coarse subrounded quartz sand, coarse broken shell fragments. No phosphate, sponge spicules rare, no Foraminifera or Ostracoda.
182′1″-183′1″	0.89	Diatomaceous clay, light olive-green; same as 180′1″-182′1″ interval with no quartz sand or shell fragments. Trace of tan clay. Sponge spicules rare, no Foraminifera or Ostracoda.
183′1″-184′1″	0.89	Diatomaceous clay, light olive-green; 85 percent light-green light-weight clay. Diatoms compose 15 percent of sample. Sponge spicules common, no Foraminifera or Ostracoda.
184′1″-185′4″	1.83	Diatomaceous clay, light olive-green; same as 183′1″-184′1″ interval.
185′4″-186′7″	1.03	Diatomaceous clay, light olive-green; same as 184′1″-185′4″ interval with trace of lignitized wood.
186′7″-187′7″	1.03	Diatomaceous clay, light olive-green; same as 185′4″-186′7″ interval.
187′7″-188′1″	1.51	Diatomaceous clay, light olive-green; same as 186′7″-187′7″ interval.
188′1″-189′1″	1.51	Diatomaceous clay, light olive-green; same as 187′7″-188′1″ interval with trace of brown to reddish-brown phosphate, tan clay. Sponge spicules common, no Foraminifera or Ostracoda.
189′1″-190′6″	1.51	Diatomaceous clay, light olive-green; same as 188′1″-189′1″ interval with no phosphate. Sponge spicules common, no Foraminifera or Ostracoda.
190′6″-191′2″	1.51	Diatomaceous clay, light olive-green; Same as 189′1″-190′6″ interval.
191′2″-193′0″	19.5	Phosphatic sand, dark greenish-brown; 45 percent fine-grained light-brown to black phosphate, 40 percent fine angular to subangular clear quartz sand, 15 percent medium to coarse subangular to subrounded clear quartz sand. Trace of medium-grained dark-brown to black phosphate. Diatoms very abundant, sponge spicules rare, no Foraminifera or Ostracoda.
193′0″-194′0″	19.5	Phosphatic sand, dark greenish-brown; same as 191′2″-193′0″ interval with medium rounded quartz sand prominent. Diatoms and sponge spicules very rare, no Foraminifera or Ostracoda.
194′0″-195′0″	16.7	Phosphatic sand and clay, medium greenish-gray; 40 percent medium angular to subangular clear quartz sand, 30 percent medium greenish-gray slightly calcareous clay, 30 percent fine to medium-grained light-brown to black phosphate. Coarse subangular to subrounded clear quartz sand and coarse-sand-size particles of dark-brown to black phosphate prominent. Trace of light-gray limestone fragments. Diatoms rare, no sponge spicules, Foraminifera or Ostracoda.
195′0″-196′6″	16.7	Phosphatic sand and clay, medium greenish-gray; same as 194′5″-195′0″ interval.
196′6″-197′1″	8.38	Phosphatic sandy limestone, medium greenish-gray, well indurated; 40 percent light-gray very fine crystalline limestone, 30 percent fine to medium-grained dark-brown to black phosphate. Coarse-sand-size particles of dark-brown to black phosphate prominent. Diatoms, Foraminifera, and sponge spicules very rare, no Ostracoda.
197′1″-197′11″	9.83	Phosphatic sandy limestone, medium greenish-gray; same as 196′6″-197′1″ interval except poorly indurated. Trace of lignitized wood.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		Foraminifera rare, no diatoms, sponge spicules, or Ostracoda.
197′11″-198′11″	11.3	Phosphatic sandy clay, medium greenish-gray; 40 percent medium greenish-gray calcareous clay, 30 percent fine angular to subangular clear quartz sand, 30 percent fine to medium-grained dark-brown to black phosphate. Light-gray limestone aggregates prominent. Trace of amber. Foraminifera and diatoms rare, no Ostracoda.
198′11″-200′6″	11.3	Phosphatic sandy clay, medium greenish-gray; same as 197′11″-198′11″ interval.
200′6″-209′6″		No sample.
209′6″-210′0″	8.74	Phosphatic sandy limestone, light greenish-gray, well indurated; 50 percent very fine crystalline light-gray limestone, 30 percent fine to medium angular to subangular clear quartz sand, 20 percent fine to medium-grained light-brown to black phosphate. Small intercalations of light greenish-gray clay compose about 20 percent of the entire interval. Trace of amber. Diatoms and Foraminifera rare, no Ostracoda.
210′0″-211′0″	8.74	Phosphatic sandy limestone, light greenish-gray; same as 209′6″-210′0″ interval.
211′0″-211′2″	8.74	Limestone, dark-gray, well indurated; very fine crystalline dark-gray to dark-brown limestone, in part phosphoritized. Spots of brown phosphoritized limestone prominent. Diatoms and Foraminifera rare, no Ostracoda.

Ransomville quadrangle RA-34-GRL

Upper Miocene—Yorktown Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
161′4″-164′6″	9.05	Phosphatic sand, dark greenish-brown; 40 percent fine to medium angular to subangular clear quartz sand, 20 percent coarse-sand to fine-gravel-size subangular to subrounded clear to frosted quartz, 15 percent coarse-sand to medium-gravel-size particles of dark-brown to black phosphate, 15 percent dark olive-green clay, 10 percent fine to medium-grained dark-brown to black phosphate. Trace of rose quartz. Foraminifera rare, no Ostracoda.
164′6″-166′0″	9.75	Phosphatic sand, dark greenish-brown; same as 161′4″-164′6″ interval.
166′0″-167′2″	9.75	Phosphatic sand and clay, dark greenish-brown; 50 percent very fine angular clear quartz sand, 20 percent dark olive-green clay, 10 percent very fine-grained light-gray to dark-brown phosphate, 10 percent coarse-sand to fine-gravel-size particles of dark-brown to black phosphate, 10 percent coarse-sand to fine-gravel-size particles of subangular to subrounded frosted to clear quartz sand. Trace of rose quartz. No microfossils.
167′2″-169′0″	6.04	Phosphatic sand and clay, dark greenish-brown; same as 166′0″-167′2″ interval with 5 percent decrease in both coarse-grained quartz sand and coarse-grained phosphate and corresponding increase in very fine quartz sand. Trace of white broken shell fragments. Foraminifera rare, no Ostracoda.

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
169′0″-171′0″	11.0	Phosphatic clay and shell, light gray-white mottled; 40 percent very fine to fine-grained light to dark-brown phosphate, 35 percent light-gray highly calcareous clay, 15 percent fine to medium white broken shell fragments, 10 percent medium subangular to subrounded clear quartz sand. Coarse-sand to fine-gravel-size particles of dark-brown to black phosphate and fine-grained light-gray weathered phosphate very prominent. Foraminifera very abundant, no Ostracoda.
171′0″-172′8″	11.0	Phosphatic limestone, gray-white mottled; 60 percent light to dark-gray fine crystalline limestone, poorly indurated, 30 percent fine-grained light to dark-brown phosphate, 10 percent fine to medium white broken shell fragments. Fine subangular to subrounded clear quartz sand prominent. Trace of coarse-grained dark-brown to black phosphate, fine-grained dark to light-green glauconite. Foraminifera very abundant, no Ostracoda.
172′8″-174′3″	3.98	Phosphatic limestone, light-gray; same as 171′0″-172′8″ interval except consolidated but soft. Foraminifera abundant, no Ostracoda.
174′3″-179′6″		No sample.
179′6″-180′7″	3.89	Shell limestone, light greenish-gray; Dark to light-gray very fine crystalline limestone, well indurated. Much of this interval consists of the casts and molds of fossils. Fine to medium white broken shell fragments and fine-grained dark-brown phosphate prominent. Foraminifera very abundant, no Ostracoda.
180′7″-182′6″	15.6	Phosphatic clay and shell, light greenish-gray; 45 percent light-gray highly calcareous clay, 30 percent fine-grained light-gray to dark-brown phosphate, 15 percent fine to medium white broken shell fragments, 10 percent fine subangular to subrounded clear quartz sand. Particles of light-gray fine crystalline limestone and fine-grained light-gray weathered phos-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		phate prominent. Trace of fine subangular to subrounded frosted quartz sand. Foraminifera abundant, sponge spicules rare, no Ostracoda.
182′6″-183′0″	7.56	Limestone, light-gray, poorly indurated; 40 percent fine to coarse-gravel-size pebbles (some are possibly fossil casts) of light-gray to tan very fine crystalline limestone, 40 percent light-gray to white fine crystalline limestone matrix, 15 percent fine-grained light-gray to dark-brown phosphate, 5 percent fine angular to subangular clear quartz sand. Foraminifera very rare, no Ostracoda or sponge spicules.
183′0″-183′8″	7.56	Phosphatic clay, light-gray; 45 percent light-gray highly calcareous clay, 15 percent fine to medium angular to subangular clear quartz sand, 40 percent fine-grained light-brown to dark-gray phosphate. Medium to coarse-grained dark-gray to dark-brown phosphate, fine to medium white broken shell fragments, particles of medium-gray fine crystalline limestone prominent. Foraminifera abundant, sponge spicules rare, no Ostracoda.
183′8″-184′8″	16.9	Phosphatic sand and clay, medium greenish-gray; 40 percent fine-grained light-gray to dark-brown phosphate, 35 percent medium olive-green clay, 15 percent fine angular to subangular clear quartz sand, 10 percent fine to coarse white broken shell fragments. Trace of tan to light-gray weathered phosphate. Foraminifera rare, no Ostracoda or sponge spicules.
184′8″-185′3″	16.9	Phosphatic sand and clay, medium greenish-gray; same as 183′8″-184′8″ interval with 10 percent decrease in shell fragments and corresponding increase in fine-grained phosphate. Foraminifera very rare, no Ostracoda.
185′3″-185′9″	6.21	Clay and phosphatic sand, dark olive-green; this interval consists of dark olive-green calcareous clay with interbedded thin layers of phosphatic sand. For entire interval: 60 percent dark olive-green calcareous clay, 30 percent fine-grained light-gray to dark-brown phosphate, 10 percent fine angular to subangular clear quartz sand. Trace of coarse subrounded clear quartz sand, coarse-grained to dark-brown phosphate. Foraminifera very rare, no Ostracoda.
185′9″-186′5″	20.3	Fossiliferous limestone, light-gray; 30 percent fossil casts of tan to light-gray limestone, 15 percent fine-grained dark-brown phosphate, 55 percent white very fine crystalline limestone matrix. Trace of medium subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.
186′5″-186′9″	20.3	Fossiliferous limestone, light-gray; same as 185′9″-186′5″ interval with Foraminifera and diatoms very rare, no Ostracoda.
186′9″-188′3″	20.3	Phosphatic sand, dark greenish-brown; 60 percent fine-grained light-gray to dark-brown phosphate, 25 percent fine angular to subangular clear quartz sand, 15 percent medium olive-green clay. Trace of coarse-grained light-gray to dark-brown phosphate, light-gray weathered phosphate. Foraminifera very rare, no diatoms or Ostracoda.
188′3″-190′9″	19.7	Phosphatic sand, dark greenish-brown; same as 186′9″-188′3″ interval with 10 percent decrease in olive-green clay and 5 percent increase in both fine-grained phosphate and fine quartz sand. Foraminifera very rare, no Ostracoda.
190′9″-193′0″	18.9	Phosphatic sand, dark greenish-brown; same as 188′3″-190′9″ interval with no microfossils.
193′0″-194′6″	15.3	Phosphatic sand, dark greenish-brown; same as 190′9″-193′0″ interval with Foraminifera rare, no Ostracoda.
194′6″-195′0″	15.3	Phosphatic sand, dark greenish-brown; same as 193′0″-194′6″ interval with 10 percent decrease in fine-grained phosphate and corresponding increase in fine quartz sand. No microfossils.
195′0″-195′8″	5.22	Phosphatic limestone, light greenish-gray, poorly indurated; 55 percent light greenish-gray limestone, 35 percent fine-grained light to dark-brown phosphate, 10 percent fine angular to subangular clear quartz sand. Trace of medium-grained dark-brown phosphate. Foraminifera common, Ostracoda rare.
195′8″-201′3″		No sample.
201′3″-201′9″	6.00	Phosphatic limestone, medium greenish-gray; same as 195′0″-195′8″ interval but well indurated. No microfossils.
201′9″-206′1″		No sample.
206′1″-208′9″	18.1	Phosphatic sand, dark greenish-brown; 45 percent fine-grained light-gray to dark-brown phosphate, 40 percent fine angular to subangular clear quartz sand, 15 percent dark olive-green clay. Trace of coarse subrounded frosted quartz sand, coarse-grained dark-brown to black phosphate. Foraminifera very rare, no Ostracoda.
208′9″-210′4″	14.8	Phosphatic sand, dark greenish-brown; same as 206′1″-208′9″ interval, with light-gray limestone pebbles prominent. Foraminifera very rare, no Ostracoda.
210′4″-216′7″		No sample.

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
216′7″-219′4″	15.9	Phosphatic sand and clay, dark greenish-brown; 45 percent fine-grained light-gray to dark-brown phosphate, 35 percent fine angular to subangular clear quartz sand, 20 percent dark olive-green clay. Trace of coarse-grained dark-brown phosphate, coarse subangular to subrounded clear quartz sand. Foraminifera very rare, no Ostracoda.
219′4″-219′8″	15.9	Phosphatic sand and clay, dark greenish-brown; 30 percent fine-grained light-gray to dark-brown phosphate, 25 percent fine angular to subangular clear quartz sand, 25 percent dark olive-green clay, 20 percent medium to coarse-gravel-size particles of tan to light-gray phosphate. Trace of medium-grained dark-brown phosphate, medium-gravel-size particles of light-gray limestone. Foraminifera very rare, no Ostracoda.
219′8″-227′4″		No sample.
227′4″-231′8″	10.2	Phosphatic sand and clay, medium greenish-gray; 50 percent very fine to fine-grained dark-brown phosphate, 25 percent medium greenish-gray clay, 20 percent fine to medium angular to subangular clear quartz sand, 5 percent coarse-grained dark-gray to dark-brown phosphate. Foraminifera rare, no Ostracoda.
231′8″-232′6″	4.07	Calcareous clay, medium greenish-gray; 90 percent medium greenish-gray highly calcareous clay, 10 percent very fine to fine-grained dark-brown phosphate. Trace of fine angular to subangular clear quartz sand. No microfossils.
232′6″-233′0″	4.07	Sand and clay, medium greenish-gray; 45 percent very fine to fine angular to subangular clear quartz sand, 30 percent medium olive-green clay, 15 percent very fine to fine-grained light to dark-brown phosphate, 10 percent medium subangular to subrounded clear quartz sand. Coarse-grained light to dark-brown phosphate prominent. Phosphoritized Foraminifera rare, no Ostracoda.
233′0″-234′11″	4.07	Clay and sand, medium olive-green; 60 percent dark olive-green clay, 30 percent fine subangular to subrounded clear quartz sand, 10 percent very fine to fine-grained light-brown to dark-gray phosphate. Trace of medium-grained tan phosphate, medium subangular to subrounded clear quartz sand. No microfossils.
234′11″-239′0″		No sample.
239′0″-241′6″	0.69	Limestone, light greenish-gray; light greenish-gray fine crystalline well indurated limestone. Trace of tan limestone, coarse-grained dark-brown phosphate, medium-grained angular to subangular clear quartz sand. Foraminifera very rare, no Ostracoda.

Eocene—Castle Hayne Limestone

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
241′6″-242′0″	0.69	Shell limestone, well indurated light-gray; 40 percent of this interval consists of casts and molds of large fossils, composed of tan, light-gray, or white limestone, 25 percent very fine to fine subangular to subrounded clear quartz sand, 35 percent very fine crystalline light-gray to white limestone matrix. Foraminifera rare, no Ostracoda.

South Creek quadrangle SC-10-GRL

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
150′0″-153′0″	6.69	Phosphatic sand, dark greenish-brown; 65 percent very fine to fine angular to subangular clear quartz sand, 25 percent fine to medium-grained dark-brown to black phosphate, 10 percent medium to coarse subangular to subrounded clear quartz sand. Trace of black clay. Foraminifera rare, no Ostracoda.
153′0″-156′4″	6.98	Phosphatic sand, dark greenish-brown; same as 150′0″-153′0″ interval.
156′4″-159′4″	5.08	Phosphatic sand, dark greenish-brown; same as 153′0″-156′4″ interval with Foraminifera common, no Ostracoda.
159′4″-159′6″	1.45	Limestone, light-gray, well indurated; light-gray microcrystalline limestone. Trace of medium subrounded to rounded clear to frosted quartz sand, very fine to medium-grained dark-brown phosphate. Foraminifera common, no Ostracoda.
159′6″-173′6″	1.23	Limestone, light olive-green, well indurated. The only recovery from this interval is a 3-inch layer of light olive-green limestone, composition as follows: 90 percent light greenish-white limestone, well indurated, 10 percent fine to medium subrounded clear quartz sand. Foraminifera common, Ostracoda rare.
173′6″-177′7″		No sample.
177′7″-178′7″	1.06	Shell limestone, light-gray, poorly indurated; 60 percent microcrystalline light-gray to white limestone matrix, 40 percent fossil casts and molds, replaced by microcrystalline limestone. Trace of very fine-grained dark-brown phosphate. Foraminifera rare, no Ostracoda.
178′7″-180′3″	1.06	Calcareous clay and shell, greenish-white; 50 percent fine to coarse white broken shell fragments, 40 percent white highly calcareous clay, 10 percent fine to medium subangular to subrounded clear quartz sand. Coarse-sand-size particles of

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		white limestone prominent. Trace of very fine-grained dark-brown phosphate. Foraminifera abundant, Ostracoda common.
180′3″-182′3″	1.86	Calcareous clay and shell, greenish-white; same as 178′7″-180′3″ interval with Foraminifera and Ostracoda abundant.
182′3″-183′4″	1.86	Calcareous clay and shell, greenish-white; same as 180′3″-182′3″ interval with fine-grained phosphate prominent. Foraminifera and Ostracoda.
183′4″-184′0″	1.67	Calcareous clay and limestone, light olive-green; 60 percent light olive-green calcareous clay, 40 percent fine to medium-sand-size particles of white limestone. Trace of fine to medium broken shell fragments, very fine-grained dark-brown phosphate. Foraminifera and Ostracoda abundant, sponge spicules rare.
184′0″-187′0″	1.67	Diatomaceous clay, greenish-white; 90 percent very light-weight greenish-white calcareous clay, 10 percent of sample composed of diatoms. Trace of fine-sand-size particles of white limestone, fine subangular to subrounded clear quartz sand, fine-grained light-gray to dark-brown phosphate. Sponge spicules common, Foraminifera and Ostracoda rare.
187′0″-190′6″	1.96	Diatomaceous clay, greenish-white; same as 184′0″-187′0″ interval with trace of fine-gravel-size particles of dark to light-gray phosphate, fine to medium light-gray to white broken shell fragments. Foraminifera abundant, sponge spicules common, Ostracoda rare.
190′6″-194′0″	3.95	Limestone and clay, greenish-white, poorly indurated; 55 percent fine to medium-sand-size particles of white limestone, 20 percent light-gray calcareous clay, 15 percent fine to medium white broken shell fragments, 10 percent fine-grained light to dark-brown phosphate. Trace of medium subangular to subrounded clear quartz sand. Foraminifera common, sponge spicules and diatoms rare, no Ostracoda.
194′0″-199′0″	5.65	Phosphatic limestone, white to light-gray, poorly indurated; 60 percent microcrystalline white to light-gray limestone matrix, 25 percent fine-grained light-gray to dark-brown phosphate, 10 percent very fine to fine angular to subangular clear quartz sand, 5 percent medium white broken shell fragments. Foraminifera common, no Ostracoda, sponge spicules, or diatoms.
199′0″-199′6″	2.82	Phosphatic limestone, white to light-gray; same as 194′0″-199′0″ interval except well indurated. Diatoms and Foraminifera rare, no Ostracoda.
199′6″-200′0″	10.6	Phosphatic sand and shell, gray-white mottled; 40 percent very fine to fine-grained light-gray to dark-brown phosphate, 35 percent fine angular to subangular clear quartz sand, 15 percent medium white broken shell fragments, 10 percent light-gray clay. Foraminifera abundant, no diatoms or Ostracoda.
200′0″-202′8″	5.77	Clay and shell, light olive-green; 60 percent light olive-green calcareous clay, 20 percent fine to medium white broken shell fragments, 10 percent fine-grained light-gray to light-brown phopshate, 10 percent very fine to fine angular to subangular clear quartz sand. Trace of coarse-sand-size light-gray limestone and phosphate aggregates. Diatoms abundant, sponge spicules, Foraminifera and Ostracoda common.
202′8″-208′0″	3.23	Diatomaceous clay, light greenish-white; 65 percent light-weight, light greenish-white calcareous clay, 20 percent diatoms, 10 percent very fine-grained dark-gray to dark-brown phosphate, 5 percent very fine to fine angular to subangular clear quartz sand. Fine to medium white broken shell fragments prominent. Trace of medium subangular to subrounded clear quartz sand. Foraminifera abundant, sponge spicules and radiolaria rare, no Ostracoda.
208′0″-208′6″		No sample.
208′6″-210′4″	18.2	Phosphatic clay and sand, light greenish-brown; 40 percent light gray clay, 30 percent very fine to fine-grained light-gray to light-brown phosphate, 25 percent fine angular to subangular clear quartz sand, 5 percent medium white broken shell fragments. Foraminifera common, radiolaria rare, no sponge spicules or Ostracoda.
210′4″-211′4″	11.5	Phosphatic clay and sand, light greenish-brown; same as 208′6″-210′4″ interval with 5 percent increase in phosphate and corresponding decrease in quartz sand. Foraminifera and Ostracoda common, diatoms and sponge spicules rare.
211′4″-214′2″	4.40	Clay, light greenish-white; this interval consists of light greenish-white clay with scattered layers of phosphatic sand. For entire interval: 70 percent light-weight, light greenish-white clay, 15 percent very fine to fine-grained light-gray to light-brown phosphate, 15 percent fine subangular to subrounded clear quartz sand. Medium white broken shell fragments and diatoms prominent. Foraminifera abundant, sponge spicules and Ostracoda rare.
214′2″-216′8″	17.3	Phosphatic sand and clay, medium greenish-gray; 45 percent fine to very fine angular to subangular

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		clear quartz sand, 30 percent fine to medium-grained light-gray to dark-brown phosphate, 25 percent light-gray calcareous clay. Trace of medium light-gray to light-brown phosphate, medium subrounded clear quartz sand, medium white broken shell fragments. Foraminifera common, no diatoms, Ostracoda or sponge spicules.
216′8″-217′4″	13.4	Phosphatic sand and clay, medium greenish-gray; same as 214′2″-216′8″ interval with Foraminifera common, diatoms and radiolaria rare, no Ostracoda.
217′4″-218′0″	16.0	Phosphatic sand, light greenish-gray; 45 percent fine-grained light-gray to dark-brown phosphate, 40 percent fine subangular to subrounded clear quartz sand, 15 percent medium-gray calcareous clay. Trace of fine to medium-sand-size aggregates of white limestone, medium-grained light-gray phosphate. Foraminifera common, no diatoms, radiolaria or Ostracoda.
218′0″-219′9″	15.3	Phosphatic sand and clay, medium greenish-gray; 40 percent medium-gray calcareous clay, 30 percent fine-grained light-brown to dark-gray phosphate, 30 percent fine subangular to subrounded clear quartz sand. Trace of medium white broken shell fragments, medium-grained dark-gray phosphate. Foraminifera very rare, no Ostracoda.
219′9″-222′0″	0.75	Limestone, light-gray, well indurated; microcrystalline white to light-gray limestone. Trace of very fine to fine-grained dark-brown phosphate. Foraminifera very rare, no Ostracoda.
222′0″-224′7″	17.2	Phosphatic sand, medium greenish-brown; 60 percent fine angular to subangular clear quartz sand, 40 percent fine-grained dark-gray to dark-brown phosphate. Light-gray calcareous clay prominent. Trace of medium white broken shell fragments, medium-grained dark-brown phosphate. Foraminifera very rare, no Ostracoda.
224′7″-227′0″	9.68	Phosphatic sand, medium greenish-brown; same as 220′0″-224′7″ interval with no shell fragments. The interval 224′7″-225′2″ is composed of poorly indurated light olive-green limestone. No microfossils.
227′0″-227′6″	16.6	Phosphatic sand, medium greenish-brown; same as 224′7″-227′0″ interval with no limestone. No microfossils.
227′6″-228′6″		No sample.
228′6″-230′6″	15.1	Phosphatic sand, medium greenish-brown; same as 227′0″-227′6″ interval with 10 percent decrease in phosphate and corresponding increase in quartz sand. Foraminifera very rare, no Ostracoda.
230′6″-233′0″	14.6	Phosphatic sand, medium greenish-brown; same as 228′6″-230′6″ interval.
233′0″-235′0″	11.2	Phosphatic sand, medium greenish-brown; same as 230′6″-233′0″ interval with trace of fine-gravel-size particles of dark-gray to dark-brown phosphate, black clay. Foraminifera and radiolaria rare, no Ostracoda.
235′0″-237′0″	9.49	Phosphatic sand, medium greenish-brown; same as 233′0″-235′0″ interval with Foraminifera common, diatoms and sponge spicules rare, no radiolaria or Ostracoda.
237′0″-240′1″	8.42	Phosphatic sand and clay, medium greenish-gray; 40 percent medium gray calcareous clay, 20 percent fine angular to subangular clear quartz sand, 20 percent fine-grained light to medium-gray phosphate with lime coating, 10 percent fine-grained light to dark-brown phosphate, 10 percent coarse-sand to medium-gravel-size particles of dark-gray to dark-brown phosphate. Foraminifera very abundant, diatoms and sponge spicules rare, no Ostracoda.
240′1″-243′6″	19.6	Phosphatic sand, medium greenish-gray; 35 percent fine subangular to subrounded clear quartz sand, 35 percent fine to medium-grained dark-gray to dark-brown phosphate, 15 percent medium-gray clay, 15 percent coarse-sand to fine-gravel-size particles of dark-gray to dark-brown phosphate. Diatoms, Foraminifera and spong spicules rare, no Ostracoda.
243′6″-244′0″	4.27	Phosphatic clay and sand, light greenish-gray; 45 percent light-gray highly calcareous clay, 25 percent fine subangular to subrounded clear quartz sand, 20 percent fine to medium-grained light to dark-brown phosphate, 10 percent coarse-sand to medium-gravel-size particles of light-gray limestone. Trace of coarse-grained light-brown phosphate. Foraminifera very rare, no diatoms, sponge spicules or Ostracoda.
244′0″-246′6″	4.82	Phosphatic sand and clay, light greenish-gray; 40 percent light-gray highly calcareous clay, 35 percent fine angular to subrounded clear quartz sand, 25 percent very fine-grained dark-brown phosphate. Trace of coarse white broken shell fragments, fine to medium-gravel-size aggregates of medium-gray limestone and phosphate. Foraminifera common, sponge spicules rare, no diatoms or Ostracoda.
246′6″-250′0″	6.51	Phosphatic sand, medium greenish-gray; 75 percent fine subangular to subrounded clear quartz sand, 25 percent very fine to fine-grained light to dark-brown phosphate. Trace of medium-grained dark-

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		brown phosphate, medium-gray clay. Foraminifera and diatoms rare, no sponge spicules or Ostracoda.
250′0″-253′0″	6.75	Phosphatic sand and clay, medium olive-green; this interval consists of alternating layers of phosphatic sand and medium olive-green clay. For entire interval: 45 percent medium olive-green clay, 30 percent very fine to fine-grained light to dark-brown phosphate, 25 percent fine subangular to subrounded clear quartz sand. Trace of medium white broken shell fragments, very fine-grained light-green glauconite. Foraminifera common, no diatoms or Ostracoda.
253′0″-256′0″	9.78	Phosphatic sand and clay, medium greenish-gray; 50 percent subangular to subrounded clear quartz sand, 30 percent very fine to fine-grained light-gray to dark-brown phosphate, 20 percent medium-gray calcareous clay. Trace of medium white broken shell fragments. Foraminifera common, no Ostracoda.
256′0″-258′5″	10.2	Phosphatic sand and clay, medium greenish-gray; same as 253′0″-256′0″ interval.
258′5″-261′0″	6.67	Clay, medium olive-green; 70 percent medium olive-green calcareous clay, 15 percent very fine to fine-grained light to dark-brown phosphate, 15 percent fine subangular to subrounded clear quartz sand. Trace of medium-grained light-gray to light-brown phosphate. Foraminifera very abundant, no Ostracoda.
261′0″-263′8″	6.67	Phosphatic clay, medium olive-green; same as 258′5″-261′0″ interval with 5 percent increase in phosphate and corresponding decrease in clay. Foraminifera abundant, no Ostracoda.
263′8″-265′3″	12.3	Phosphatic clay, dark olive-green; 55 percent very fine to medium-grained light-gray to dark-brown phosphate, 15 percent very fine angular to subangular clear quartz sand, 30 percent dark olive-green calcareous clay. Coarse-sand to fine-gravel-size particles of dark-gray phosphate prominent. Trace of medium white broken shell fragments. Foraminifera abundant, no Ostracoda.
265′3″-266′0″	18.0	Phosphatic sand, dark greenish-brown; 55 percent very fine to medium-grained light-brown to dark-gray phosphate, 35 percent very fine angular to subangular clear quartz sand, 10 percent fine to medium light-gray particles of phosphate with lime coating. Coarse-sand to fine-gravel-size particles of dark-gray phosphate prominent. Trace of coarse white broken shell fragments. Foraminifera common, no Ostracoda.
266′0″-272′0″	4.39	Limestone, dark-gray, well indurated; dark-gray very fine crystalline limestone. Trace of very fine to fine-grained light-brown to dark-gray phosphate, fine to medium subangular to subrounded clear quartz sand. The lower 6 inches of this interval contains fine to medium-gravel-size particles of dark-gray to black phosphate. For entire interval: Foraminifera very rare, no Ostracoda.

South Creek quadrangle SC-17-GRL

Middle Miocene—Pungo River Formation

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
120′0″-123′6″	1.21	Clay, medium olive-green; 75 percent medium olive-green clay, 15 percent fine subangular to subrounded clear quartz sand, 10 percent fine-grained dark-brown to black phosphate. Foraminifera and Ostracoda rare.
123′6″-126′8″	6.21	Phosphatic sand and clay, medium greenish-gray; 45 percent fine angular to subangular clear quartz sand, 30 percent medium-gray clay, 25 percent fine-grained dark-brown to black phosphate. Trace of coarse subrounded frosted quartz sand, coarse-sand to fine-gravel-size particles of dark-gray to black phosphate. Foraminifera very rare, no Ostracoda.
126′8″-130′0″	6.41	Phosphatic sand and clay, medium greenish-gray; same as 123′6″-126′8″ interval.
130′0″-133′7″	4.91	Phosphatic sand and clay, medium greenish-gray; same as 126′8″-130′0″ interval with no microfossils.
133′7″-136′11″	6.58	Sand and clay, medium greenish-gray; 55 percent very fine to fine angular to subangular clear quartz sand, 35 percent medium-gray clay, 10 percent very fine to fine-grained dark-brown to black phosphate. Trace of rose quartz, coarse-grained dark-gray to dark-brown phosphate, coarse subrounded clear to frosted quartz sand. Foraminifera and Ostracoda very rare.
136′11″-140′0″	9.31	Phosphatic sand, medium greenish-gray; 50 percent very fine to fine angular to subangular clear quartz sand, 20 percent fine subrounded to rounded frosted quartz gravel, 20 percent fine-gravel-size particles of dark-brown to dark-gray phosphate, 10 percent fine-grained light to dark-brown phosphate. Foraminifera rare, no Ostracoda.
140′0″-142′4″		No sample.
142′4″-145′5″	6.08	Phosphatic sand, dark greenish-brown; 70 percent very fine angular to subangular clear quartz sand, 15 percent very fine to medium grained dark-brown to black phosphate, 10 percent coarse-sand

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		to fine-gravel-size particles of clear to frosted quartz. Coarse-sand to fine-gravel-size particles of dark-brown to dark-gray phosphate prominent. Trace of rose quartz, fine-grained light-green glauconite. Foraminifera very rare, no Ostracoda.
145′5″-147′7″	5.72	Phosphatic sand, medium greenish-brown; 65 percent very fine angular clear quartz sand, 25 percent very fine to medium-grained light-brown to black phosphate, 10 percent medium subangular to subrounded clear quartz sand. Trace of meduim-gray clay, coarse-grained dark-brown to black phosphate, very fine-grained light-green glauconite. No microfossils.
147′7″-151′0″	4.79	Phosphatic sand, medium greenish-brown; same as 145′5″-147′7″ interval with Foraminifera rare, no Ostracoda.
151′0″-170′0″		No sample.
170′0″-178′0″	1.50	Phosphatic limestone, light greenish-gray to dark-gray, well indurated. The upper two-thirds of this interval consists of light greenish-gray well indurated limestone. The lower one-third consists of dark-gray well indurated limestone. For entire interval: 60 percent microcrystalline limestone, dark-gray to light greenish-gray, 20 percent fossil casts and molds, replaced by limestone, 20 percent very fine to fine-grained dark-brown to black phosphate. Fine subangular to subrounded clear quartz sand prominent. No microfossils.
178′0″-180′4″	4.85	Phosphatic limestone, greenish-white, poorly indurated; 60 percent white microcrystalline limestone matrix, 25 percent very fine to fine-grained dark-brown phosphate, 15 percent fine subangular to subrounded clear quartz sand. Coarse-sand to medium-gravel-size well indurated aggregates of white limestone and phosphate prominent. Foraminifera common, Ostracoda rare.
180′4″-181′6″	11.4	Phosphatic sand and limestone, greenish-white; 35 percent fine subangular to subrounded clear quartz sand, 30 percent fine-grained light to dark-brown phosphate, 20 percent fine to coarse-sand-size particles of white limestone, 15 percent greenish-white calcareous clay. Fine to medium-gravel-size aggregates of white limestone and phosphate prominent. Foraminifera very abundant, no Ostracoda.
181′6″-182′6″	5.53	Clay and shell, light greenish-gray; 45 percent medium greenish-gray calcareous clay, 40 percent medium to coarse white broken shell fragments, 15 percent very fine-grained dark-brown phosphate. Fine to medium subangular to subrounded clear to frosted quartz sand prominent. Foraminifera very abundant, Ostracoda common.
182′6″-183′6″	1.80	Clay, light olive-green; 85 percent light olive-green calcareous clay, 15 percent fine to medium-sand-size particles of white limestone. Trace of fine-grained dark-brown to dark-gray phosphate. Foraminifera and Ostracoda abundant.
183′6″-184′9″	1.43	Limestone and clay, light greenish-gray, poorly indurated. This interval consists of alternating layers of light-gray limestone and greenish-gray calcareous clay. For entire interval: 80 percent light-gray limestone, poorly indurated, 20 percent light greenish-gray calcareous clay. Trace of very fine-grained light-brown to black phosphate. Foraminifera and sponge spicules common, diatoms and Ostracoda rare.
184′9″-185′9″	5.82	Clay and limestone, medium olive-green; 60 percent medium olive-green calcareous clay, 20 percent fine-sand-size particles of white limestone, 10 percent coarse-sand to fine-gravel-size particles of white limestone, 10 percent very fine to fine-grained light to dark-brown phosphate. Fine to medium subangular to subrounded clear quartz sand prominent. Foraminifera and Ostracoda abundant, sponge spicules rare, no diatoms.
185′9″-186′11″	5.16	Limestone and clay, greenish-white; same as 184′9″-185′9″ interval with 20 percent increase in fine sand-size particles of limestone and corresponding decrease in clay. Foraminifera common, no Ostracoda or sponge spicules.
186′11″-189′6″	3.70	Clay, limestone and sand, greenish-white; 40 percent light greenish-white calcareous clay, 30 percent fine to medium-sand-size particles of white limestone, 20 percent very fine to fine angular to subangular clear to frosted quartz sand, 10 percent very fine-grained light-gray to dark-brown phosphate. Coarse-sand to fine-gravel-size particles of white limestone prominent. Foraminifera abundant, diatoms and sponge spicules rare, no Ostracoda.
189′6″-191′2″	1.60	Clay, light greenish-white; lightweight light greenish-white clay. The upper 2 inches of this interval contains medium to coarse broken shell fragments, traces of fine subangular clear quartz sand and fine to medium-grained light-gray to dark-brown phosphate. For entire interval: Diatoms very abundant, Foraminifera common, no sponge spicules or Ostracoda.
191′2″-192′0″	7.75	Phosphatic sand and clay, light greenish-brown; 35 percent very fine to fine angular to subangular

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		clear quartz sand, 30 percent very fine to fine light to dark-brown phosphate, 20 percent light greenish-gray calcareous clay, 15 percent fine to medium-sand-size particles of white limestone. Trace of medium subrounded clear quartz sand, medium white broken shell fragments. Foraminifera very abundant, diatoms and Ostracoda rare.
192′0″-192′5″	0.50	Limestone, light greenish-white, poorly indurated; light greenish-white microcrystalline poorly indurated limestone. Trace of fine-grained dark-brown phosphate, fine to medium subrounded clear quartz sand. Foraminifera and Ostracoda common, diatoms rare.
192′5″-194′11″	0.78	Clay, light greenish-white; 90 percent light greenish-white calcareous clay, 10 percent of sample is composed of very fine to fine-sand-size particles of white limestone. Trace of fine-grained dark-brown phosphate, fine subangular to subrounded clear quartz sand. Foraminifera very abundant, diatoms and sponge spicules rare, no Ostracoda.
194′11″-197′5″	0.83	Clay, light greenish-white; same as 192′5″-194′11″ interval.
197′5″-200′0″	0.75	Clay, light greenish-white; same as 194′11″-197′5″ interval.
200′0″-201′8″	9.54	Phosphatic sand, medium greenish-gray; 45 percent fine angular to subangular clear quartz sand, 40 percent fine-grained light to dark-brown phosphate, 15 percent light greenish-gray clay. Trace of fine-sand-size white limestone particles, medium subrounded clear to frosted quartz sand. Foraminifera abundant, no diatoms, sponge spicules or Ostracoda.
201′8″-204′4″	13.1	Phosphatic sand, medium greenish-gray; same as 200′0″-201′8″ interval.
204′4″-206′10″	10.8	Phosphatic sand, medium greenish-gray; same as 201′8″-204′4″ interval.
206′10″-209′0″	7.34	Sand and clay, light greenish-white; 55 percent light greenish-white highly calcareous clay, 20 percent fine angular to subangular clear quartz sand, 15 percent fine-grained dark-gray to dark-brown phosphate, 10 percent fine to medium white broken shell fragments. Trace of coarse-sand-size particles of dark-brown phosphate. Foraminifera abundant, no Ostracoda.
209′0″-220′0″		No sample.
220′0″-220′8″	2.35	Limestone and clay, medium greenish-gray; 50 percent coarse-sand to medium-gravel-size particles of light greenish-gray fine crystalline limestone, 30 percent light-gray calcareous clay, 10 percent fine to medium angular to subrounded clear quartz sand, 10 percent fine-grained dark-gray to dark-brown phosphate. Foraminifera very rare, no Ostracoda.
220′8″-222′2″	10.9	Phosphatic sand, dark greenish-brown; 60 percent fine subangular to subrounded clear quartz sand, 40 percent fine-grained dark-brown to black phosphate. Trace of fine to medium white broken shell fragments, coarse-grained dark-brown to black phosphate, coarse subrounded clear quartz sand. Foraminifera rare, no Ostracoda.
222′2″-224′0″	13.5	Phosphatic sand, dark greenish-brown; same as 220′8″-222′2″ interval.
224′0″-225′10″	16.0	Phosphatic sand, dark greenish-brown; same as 222′2″-224′0″ interval with 10 percent increase in phosphate and corresponding decrease in quartz sand. Foraminifera very rare, no Ostracoda.
225′10″-228′10″	9.89	Phosphatic sand, dark greenish-brown; same as 224′0″-225′10″ interval with no microfossils.
228′10″-234′0″	1.27	Diatomaceous clay, light olive-green; 80 percent light-weight, light olive-green clay, 20 percent of sample is composed of diatoms. Trace of fine to medium subangular to subrounded clear quartz sand, fine-grained dark-brown to black phosphate. No Foraminifera or Ostracoda.
234′0″-236′7″	1.25	Clay, light olive-green; 80 percent light-weight, light olive-green clay, 10 percent fine to medium-grained light-gray to dark-brown phosphate, 10 percent fine to medium-grained rounded clear quartz sand. Diatoms and sponge spicules abundant, no Foraminifera or Ostracoda.
236′7″-238′0″	11.5	Phosphatic sand and clay, medium olive-green. The upper 5 inches of this interval consists of dark greenish-brown phosphatic sand. The lower 1 foot consists of phosphatic clay and sand, medium olive-green, composition as follows: 60 percent medium olive-green clay, 20 percent fine-grained dark-gray to dark-brown phosphate, 20 percent fine subangular to subrounded clear quartz sand. Trace of medium-grained dark-brown to black phosphate. No microfossils.
238′0″-242′0″	4.02	Phosphatic clay and sand, medium olive-green; same as 237′0″-238′0″ interval with trace of calcite and dolomite rhombohedrons. Foraminifera very rare, no Ostracoda.
242′0″-243′2″	4.71	Phosphatic limestone, light olive-green, poorly indurated; 65 percent fine crystalline light olive-green poorly indurated limestone, 25 percent very fine-grained dark-brown to black phosphate, 10 percent fine

Depth Interval (feet)	P_2O_5 Content (percent)	Lithology
		subangular to subrounded clear quartz sand. Trace of medium grained dark-gray to dark-brown phosphate. No microfossils.
243′2″-246′2″	13.1	Phosphatic sand, medium greenish-gray; 45 percent fine subangular to subrounded clear quartz sand, 40 percent very fine to fine-grained dark-brown to black phosphate, 15 percent medium-gray clay. Trace of coarse subrounded clear to frosted quartz sand, medium to coarse white broken shell fragments, coarse-grained dark-gray to dark-brown phosphate. No microfossils.
246′2″-248′4″	12.3	Phosphatic sand, medium greenish-gray; same as 243′2″-246′2″ interval with Foraminifera rare, no Ostracoda.
248′4″-249′6″	8.76	Phosphatic sand, medium greenish-gray; same as 246′2″-248′4″ interval with Foraminifera common, no Ostracoda.
249′6″-250′8″	2.65	Phosphatic clay and sand, dark olive-green; 60 percent dark olive-green clay, 20 percent very fine to fine-grained light-gray to dark-brown phosphate, 20 percent fine subangular to subrounded clear quartz sand, fine to medium white broken shell fragments. Foraminifera rare, no Ostracoda.
250′8″-253′2″	13.5	Phosphatic clay, dark greenish-gray; 60 percent very fine to fine-grained light to dark-brown phosphate, 25 percent medium greenish-gray clay, 15 percent fine angular to subangular clear quartz sand. Trace of coarse-sand to fine-gravel-size particles of light-brown to light-gray phosphate. Foraminifera very rare, no Ostracoda.
253′2″-256′11″	5.43	Phosphatic clay, medium olive-green. The upper 6 inches of this interval is dark greenish-gray phosphatic clay, same as 250′8″-253′2″ interval. The lower 3′3″ of the interval consists of medium olive-green phosphatic clay, composition as follows: 80 percent medium olive-green calcareous clay, 20 percent very fine-grained light to dark-brown phosphate. Trace of medium subrounded clear to frosted quartz sand, coarse-grained dark to light-gray phosphate, very fine-grained light-green glauconite. Foraminifera, diatoms and radiolaria rare, no Ostracoda.

Beneficiation Data

The laboratory beneficiation data in Table 1 were obtained by the following procedures; (1) determining the dry weight and $P_2 O_5$ content expressed as BPL content) of the raw core sample, (2) separating the fraction of the total sample greater than 20 mesh (+20 mesh) in diameter and determining the BPL content and the percentage, or content, of other pertinent constituents of the +20 mesh fraction, and (3) separating the —20 mesh to +150 mesh fraction of the sample, beneficiating this fraction in a floatation cell and determining the BPL and other pertinent constituent contents of the beneficiated material.

The tonnages, or reserves, represented by the core samples that were beneficiated are included in the tables expressed as tons per acre per foot of thickness (TPA/Ft). Estimates of the total phosphate tonnage that underlies Beaufort County are not included in this report. However the reader may grossly estimate the tonnage for a particular area by comparing the lithology and $P_2 O_5$ content of the material that underlies the area with similiar material that is included in the beneficiation data tables. The location of the core holes, given in Table 1, are shown on figure 5.

Gamma-ray and Resistivity Logs

Selected gamma-ray and resistivity logs that were obtained as part of this investigation are included in this section and arranged according to quadrangle and numbered consecutively. The vertical, or depth, scale for all the logs is 50 feet per 0.65 inch; the zero depth on each log represents land surface. The horizontal scale, or sensitivity, for all the gamma-ray logs is 0.02 milliroentgens per hour (Mr/h) of gamma-ray emission for full deflection across the chart. The horizontal scale for full deflection of the resistivity logs is varied and is noted on individual logs.

SELECTED REFERENCES

Brown, P. M., 1958, The relation of phosphorites to ground water in Beaufort County, North Carolina: Econ. Geology, v. 53, p. 85-101.

———— 1959, The geology and ground-water resources of the Greenville area, North Carolina: North Carolina Dept. Conserv. and Devel. Bull. 73, 87 p.

Clark, W. B., Miller, B. L., Stephenson, L. W., Johnson, B. L., and Parker, H. N., 1912, The Coastal Plain of North Carolina: North Carolina Geol. and Econ. Survey, v. 3, 552 p.

Kimrey, Joel O., 1962, Delineation of phosphorite deposits with gamma-ray logs in Beaufort County, North Carolina (abs): Geol. Soc. America Special Paper 73, page 186.

———— 1964, The Pungo River Formation, a new name for middle Miocene phosphorites in Beaufort County, North Carolina: Southeastern Geology, v. 5, no. 4, p. 195-205.

Table 1. Beneficiation data for selected core s

CORE HOLE NO. PA-31-GRL

Total Sample					+20 Mesh Fraction of Total Sample							
Depth Interval	Core Length	Wet Weight (lbs)	% Moisture	BPL	% of Total Sample	Weight (lbs)	TPA Ft(2)	BPL(1)	% Insoluble Material	% Iron (Fe_2O_3)	% Aluminum (Al_2O_3)	% CaO
212′4″ — 217′0″	4′8″	16.0	26.0	45.0	4.2	0.50	84	62.3	11.0	0.94	0.51	45.4
CORE HOLE NO. RA-34-GRL												
186′5″ — 193′0″	6′7″	37.5	26.3	45.0	3.6	1.00	72	65.7	6.2	0.66	0.54	47.4
206′1″ — 219′8″	13′7″	35.5	22.7	38.1	6.4	1.75	128	62.0	7.6	0.70	0.44	45.2
CORE HOLE NO. PB-4-GL												
189′6″ — 193′10″	4′4″	17.0	24.0	34.6	13.6	1.75	271	61.2	7.0	0.74	0.33	45.7
213′5″ — 219′10″	6′5″	32.0	25.7	46.4	3.7	0.88	74	63.5	6.3	0.76	0.61	48.3
223′6″ — 239′6″	16′0″	27.0	22.0	25.0	3.0	0.63	60	60.5	11.9	0.68	0.42	44.6
239′6″ — 247′0″	7′6″	25.5	26.8	21.7	2.9	0.53	58	64.2	7.8	1.64	0.61	46.3
247′0″ — 255′6″	8′6″	41.0	21.3	34.8	11.5	3.72	229	54.1	6.5	0.82	0.37	42.3
CORE HOLE NO. PB-2-GRL												
231′9″ — 236′1″	4′4″	24.5	23.0	22.4	3.2	0.61	64	20.8	67.0	0.82	0.61	16.5

(1) Bone Phosphate of Lime (Approximately 2.18 X % P_2O_5)

(2) Tons per Acre per Foot

(3) Perce

Beneficiation data for selected core samples f

CORE HOLE NO. BE-8-GRL

Total Sample				+20 Mesh Fraction of Total Sample								
Depth Interval	Core Length	Wet Weight (lbs)	% Moisture	% of Total Sample	Weight (lbs)	TPA/Ft(2)	BPL(1)	% Insoluble Material	% Iron (Fe_2O_3)	% Aluminum (Al_2O_3)	% CaO	De Inte
219′5″ — 230′0″	10′7″	35.5	14.3	4.1	1.25	76	63.1	6.3	0.76	0.42	46.08	219′5″
CORE HOLE NO. BE-6-L												
172′0″ — 182′0″	10′0″	36.0	12.2	7.9	2.25	166	27.3	58.2	0.80	0.17	19.34	172′0″
CORE HOLE NO. PI-5-GRL												
131′6″ — 136′0″	4′6″	23.0	13.7	17.7	3.50	366	60.1	7.8	0.76	0.56	45.58	131′6″
CORE HOLE NO. SC-10-GRL												
150′0″ — 159′4″	9′4″	41.5	18.1	9.6	3.25	205	19.4	67.9	1.26	0.14	15.80	150′0″
214′2″ — 216′8″	2′6″	8.5	24.7	7.8	0.50	156	52.9	12.5	0.84	0.33	44.08	214′2″
222′0″ — 224′7″	2′7″	9.5	18.4	9.6	0.75	191	56.0	12.0	0.78	0.38	43.88	222′0″
224′7″ — 227′0″	2′5″	9.0	20.4	5.3	0.38	106	53.6	13.2	0.74	0.39	43.48	224′7″
227′0″ — 235′0″	8′0″	33.0	14.0	4.4	1.25	99	37.8	8.3	0.70	0.10	47.56	227′0″
240′1″ — 243′6″	3′5″	15.0	15.8	33.7	4.25	680	60.3	6.3	0.78	0.59	45.68	240′1″
CORE HOLE NO. SC-17-GRL												
133′7″ — 136′11″	3′4″	15.5	19.0	15.9	2.00	295	41.6	36.4	1.10	0.43	30.14	133′7″
136′11″ — 145′5″	8′6″	29.5	11.9	30.8	8.00	754	35.6	44.9	1.02	0.31	26.16	136′11″
145′5″ — 151′0″	5′7″	25.5	17.5	6.0	1.25	133	21.6	16.6	1.12	0.17	16.00	145′5″

(1) Bone Phosphate of Lime (Approximately 2.18 X % P_2O_5)

(2) Tons per Acre per Foot

(3) Perce

from core holes: PA-31, RA-34, PB-4 and PB-2.

CORE HOLE NO. PA-31-GRL

20 + 150 Mesh Fraction of Total Sample						Concentrate (—20 + 150 Mesh Fraction Beneficiated)							
h al	% of Total Sample	Weight (lbs)	TPA/Ft	BPL	% of Fraction	TPA/Ft	BPL	% Insoluble Material	% Iron (Fe_2O_3)	% Aluminum (Al_2O_3)	% CaO	P_2O_5/CaO Ratio	%[3] Metal. Recovery
217′4″	61.9	7.3	1240	48.4	68.6	848	65.8	3.2	0.38	0.43	46.9	1.56	96.0

CORE HOLE NO. RA-34-GRL

193′0″	70.6	19.5	1404	50.9	69.8	985	65.1	3.6	0.44	0.33	45.9	1.54	90.0
219′8″	71.2	19.5	1418	40.0	52.5	744	65.1	3.8	0.36	0.34	45.7	1.53	86.3

CORE HOLE NO. PB-4-GL

193′10″	31.8	4.1	631	45.9	66.7	423	66.1	2.6	0.42	0.45	47.6	1.57	95.8
219′10″	64.7	15.4	1295	53.0	72.8	943	64.0	4.0	0.44	0.36	44.3	1.51	91.5
239′6″	54.0	11.4	1077	32.0	44.3	475	64.0	3.7	0.48	0.42	45.3	1.55	91.5
247′0″	61.0	11.4	1217	28.7	41.1	501	64.9	4.0	0.86	0.42	42.0	1.41	85.5
255′6″	70.6	22.8	1408	35.7	45.1	634	65.1	3.0	0.78	0.42	43.8	1.47	80.7

CORE HOLE NO. PB-2-GRL

236′1″	73.0	13.8	1450	22.8	26.2	381	64.7	5.8	0.76	0.34	44.3	1.50	75.0

etallurgical Recovery

e holes: BE-8, BE-6, PI-5, SC-10 and SC-17.

CORE HOLE NO. BE-8-GRL

Mesh Fraction of Total Sample					Concentrate (—20 + 150 Mesh Fraction Beneficiated)							
% of Total Sample	Weight (lbs)	TPA/Ft	BPL	% of Fraction	TPA/Ft	BPL	% Insoluble Material	% Iron (Fe_2O_3)	% Aluminum (Al_2O_3)	% CaO	P_2O_5/CaO Ratio	%[3] Metal. Recovery
91.1	27.7	1685	42.9	60.7	1021	66.9	5.0	0.56	0.52	—	—	92.7

CORE HOLE NO. BE-6-L

87.7	27.7	1845	10.6	17.3	319	66.1	6.0	0.92	0.80	—	—	91.5

CORE HOLE NO. PI-5-GRL

73.7	14.6	1580	19.9	28.0	427	62.9	2.4	0.86	0.58	—	—	89.9

CORE HOLE NO. SC-10-GRL

76.5	26.0	1730	14.1	18.5	304	69.4	1.4	0.60	0.36	51.20	1.61	91.7
76.6	4.9	1520	40.0	56.9	868	63.8	2.2	0.68	0.38	—	—	89.4
83.3	6.5	1645	35.5	51.4	845	63.6	4.9	0.50	0.39	—	—	92.3
68.1	4.9	1320	33.9	56.3	766	60.7	3.5	0.48	0.17	47.20	1.70	94.7
85.9	24.4	1950	28.1	40.6	785	63.1	1.1	0.62	0.28	—	—	90.5
51.6	6.5	1030	32.6	45.8	467	65.3	4.7	0.79	0.30	47.50	1.59	87.4

CORE HOLE NO. SC-17-GRL

″	26.2	3.3	465	10.9	9.1	45	66.5	2.4	0.88	0.39	47.70	1.57	61.1
″	56.2	14.6	1380	12.1	11.1	152	66.9	2.3	0.44	1.00	48.90	1.60	62.7
	69.5	14.6	1520	13.0	8.4	130	67.6	0.9	0.39	0.87	48.50	1.57	45.8

tallurgical Recovery

Beneficiation data for selected core samples fro

CORE HOLE NO. PI-16-GRL

Total Sample					+20 Mesh Fraction of Total Sample							
Depth Interval	Core Length	Wet Weight (lbs)	% Moisture	BPL⁽¹⁾	% of Total Sample	Weight (lbs)	TPA/Ft⁽²⁾	BPL⁽¹⁾	% Insoluble Material	% Iron (Fe_2O_3)	% Aluminum (Al_2O_3)	% CaO
106′4″ — 110′1″	3′9″	22.5	23.0	27.6	6.5	1.13	130	55.0	11.8	1.00	0.49	42.6
110′9″ — 115′10″	5′1″	26.0	26.2	42.3	8.5	1.63	169	57.8	5.9	0.68	0.35	44.6
111′9″ — 115′2″	3′5″	14.0	23.3	43.2	9.3	1.00	106	60.1	7.2	0.82	0.51	44.3
120′1″ — 122′9″	2′8″	11.5	20.1	34.1	5.4	0.50	108	57.4	11.0	0.90	0.58	43.7
CORE HOLE NO. PI-23-GRL												
101′2″ — 106′11″	5′9″	30.0	22.2	38.1	5.9	1.38	138	59.0	14.1	0.84	0.52	42.9
115′6″ — 122′10″	7′4″	33.5	26.9	35.2	16.3	4.00	325	61.0	9.3	0.84	0.83	44.0
CORE HOLE NO. PA-22-GRL												
143′0″ — 146′10″	3′10″	21.5	22.7	41.9	7.5	1.25	150	62.3	7.6	0.58	0.47	46.0
CORE HOLE NO. PA-24-GRL												
170′0″ — 174′9″	4′9″	21.0	23.3	44.6	7.8	1.25	156	63.0	7.6	0.56	0.51	45.7
CORE HOLE NO. RA-13-GRL												
191′2″ — 196′8″	5′6″	22.0	22.1	41.6	8.8	1.50	176	57.6	9.7	1.16	0.63	44.0
CORE HOLE NO. BE-2-GRL												
234′5″ — 239′4″	4′11″	24.0	22.4	35.5	4.7	0.88	94	62.6	7.2	0.74	0.37	47.1
239′4″ — 245′8″	6′4″	32.0	22.0	42.7	4.5	1.13	90	61.9	9.8	3.14	1.76	42.3
259′10″ — 262′8″	2′10″	14.0	25.8	32.3	8.4	0.88	167	33.3	49.5	0.96	0.64	25.6

(1) Bone Phosphate of Lime (Approximately 2.18 X % P_2O_5)

(2) Tons per Acre per Foot

holes: PI-16, PI-23, PA-22, PA-24, RA-13 and BE-2.

CORE HOLE NO. PI-16-GRL

- 150 Mesh Fraction of Total Sample					Concentrate (—20 + 150 Mesh Fraction Beneficiated)								
l	% of Total Sample	Weight (lbs)	TPA/Ft	BPL	% of Fraction	TPA/Ft	BPL	% Insoluble Material	% Iron (Fe_2O_3)	% Aluminum (Al_2O_3)	% CaO	P_2O_5/CaO Ratio	% [3] Metal. Recovery
110'1"	65.9	11.4	1315	31.6	46.4	609	63.8	1.6	0.36	0.44	47.1	1.61	94.3
115'10"	84.9	16.3	1687	45.3	67.7	1144	66.5	1.3	0.34	0.45	47.4	1.56	96.6
115'2"	68.2	7.3	1368	46.6	67.6	921	66.6	1.8	0.36	0.39	47.4	1.55	95.6
122'9"	88.0	8.1	1769	40.3	58.8	1035	65.7	2.2	0.38	0.31	47.7	1.58	96.3

CORE HOLE NO. PI-23-GRL

106'11"	76.8	17.9	1532	43.4	62.2	952	62.0	1.1	0.42	0.50	47.4	1.54	96.9
122'10"	66.5	16.3	1323	39.4	56.7	753	66.8	1.9	0.34	0.40	47.1	1.54	97.4

CORE HOLE NO. PA-22-GRL

146'10"	78.3	13.0	1554	45.6	65.4	1021	67.0	1.3	0.40	0.47	47.7	1.55	97.2

CORE HOLE NO. PA-24-GRL

174'9"	80.7	13.0	1609	47.6	68.1	1095	66.8	2.0	0.44	0.43	47.1	1.54	98.0

CORE HOLE NO. RA-13-GRL

196'8"	85.4	14.6	1705	43.9	63.5	1085	65.9	2.3	0.44	0.46	47.1	1.56	96.6

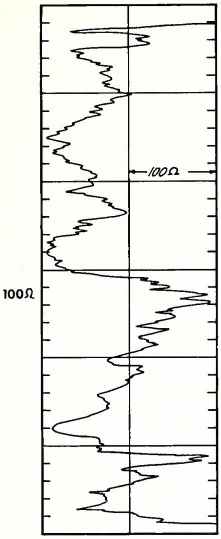
CORE HOLE NO. BE-2-GRL

239'4"	52.7	9.8	1055	42.5	60.4	634	67.3	0.9	0.26	0.34	48.3	1.57	95.2
245'8"	65.2	16.3	1296	47.4	63.3	823	67.5	1.1	0.24	0.18	47.6	1.54	92.6
- 262'8"	47.1	4.9	933	32.8	42.4	398	63.1	4.0	0.56	0.62	45.7	1.58	82.8

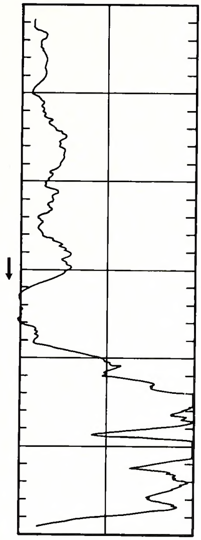
ge of Metallurgical Recovery

PLATE #1

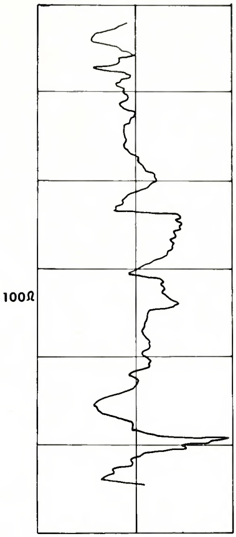
Geophysical logs in Belhaven Quadrangle



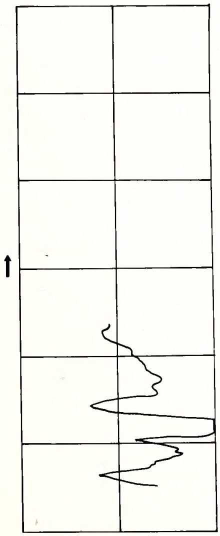
BE–1GR



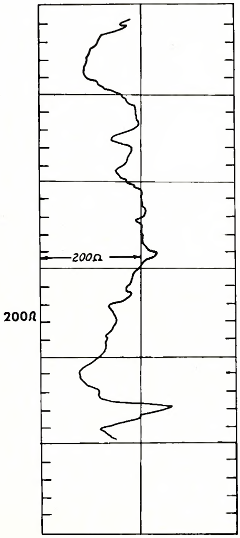
BE–1GR



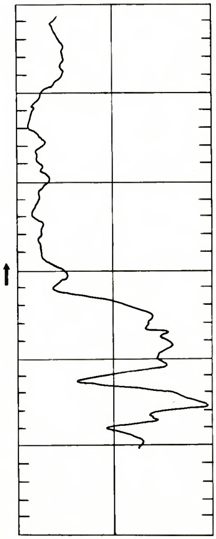
BE–2GRL



BE– 2GRL

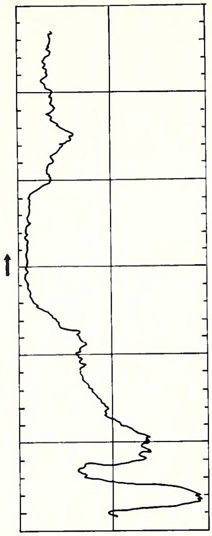


BE–3GRL

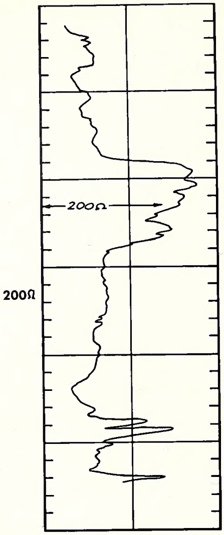


BE–3GRL

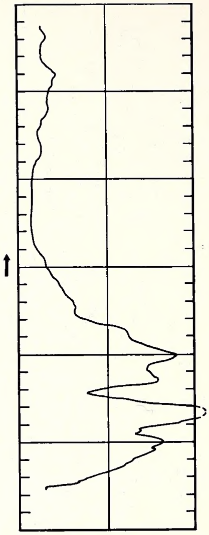
PLATE #1 (continued)



BE–4G

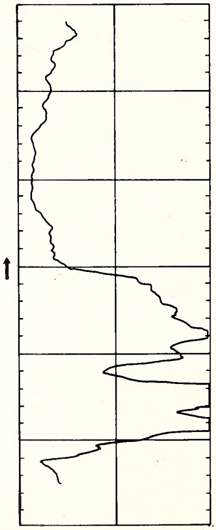


BE–5GR

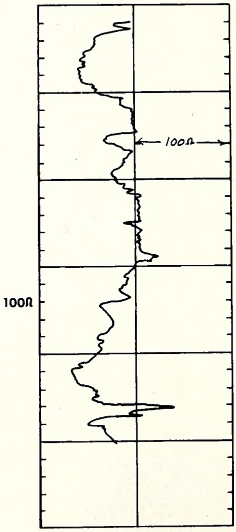


BE–5GR

LITHOLOGIC LOG ONLY
BE–6L

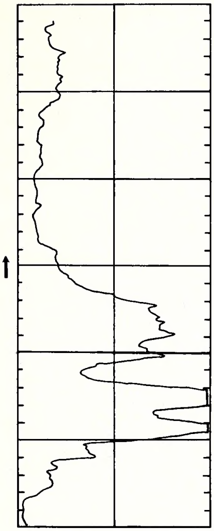


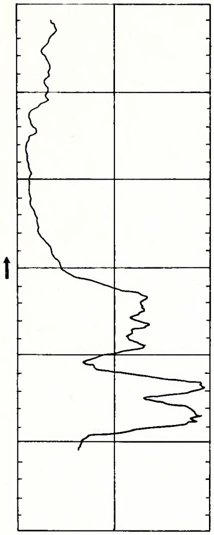
BE–7G

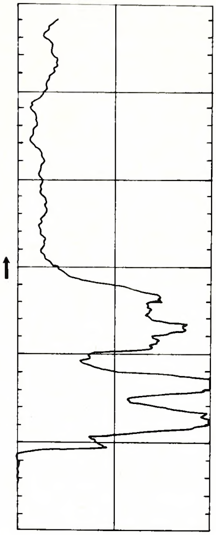


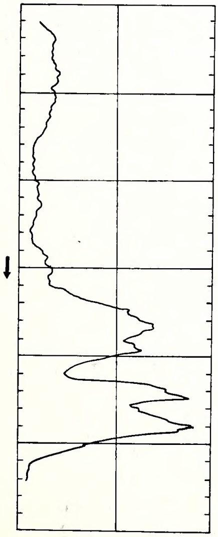
BE–BGRL

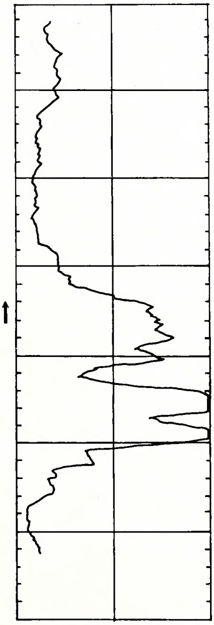
PLATE #1 (continued)


BE—8GRL


BE—9G


BE—10G


BE—11G


BE—12GL

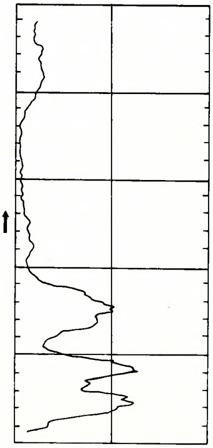
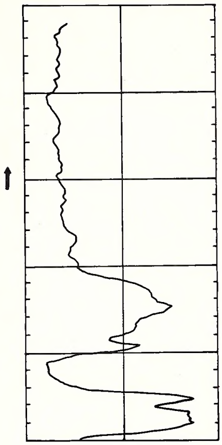
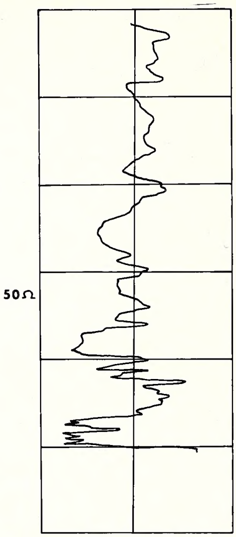

BE—13G

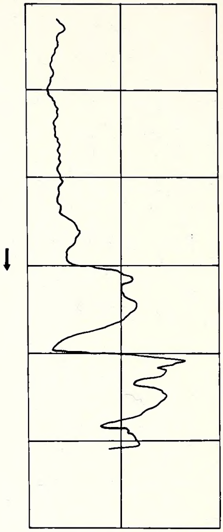
PLATE #2
Geophysical logs in Pamlico Beach Quadrangle



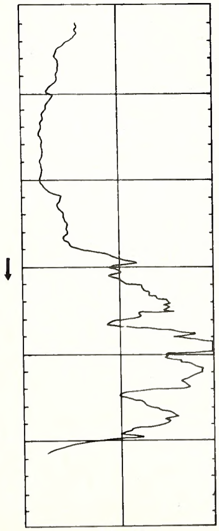
PB–1G



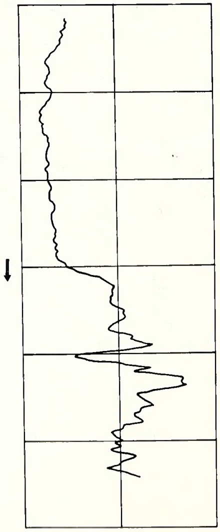
PB–2–GRL



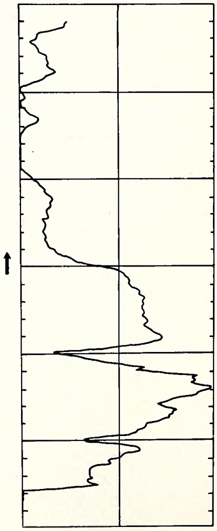
PB–2–GRL



PB–3G



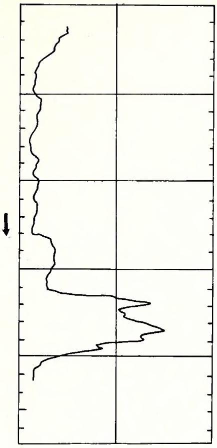
PB–4–GL



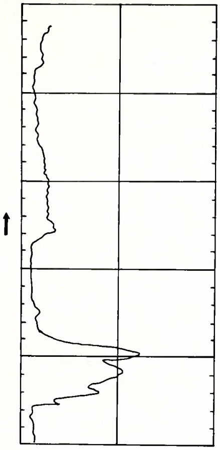
PB–5G

PLATE #3

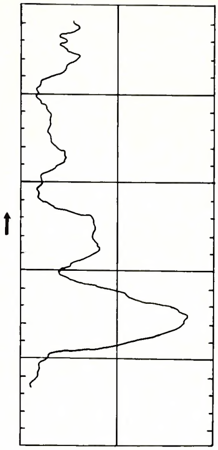
Geophysical logs in Pantego Quadrangle



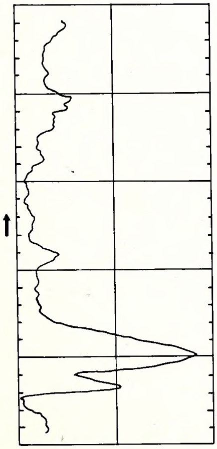
PA-1G



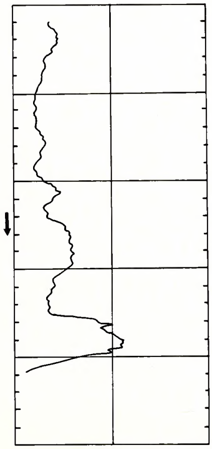
PA-2G



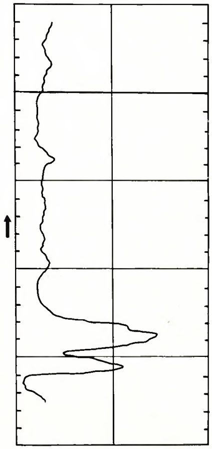
PA-3G



PA-4G

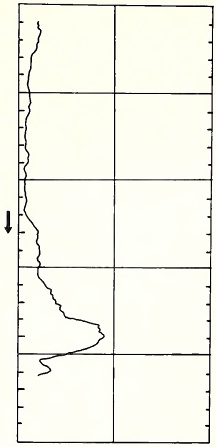


PA-5G

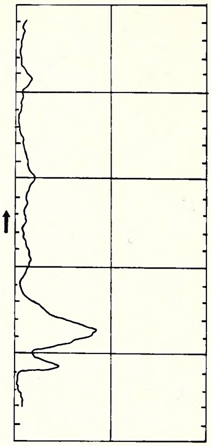


PA-6G

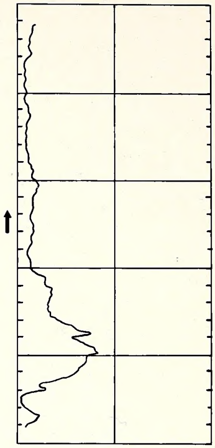
PLATE #3 (continued)



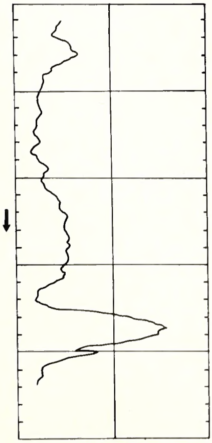
PA—7G



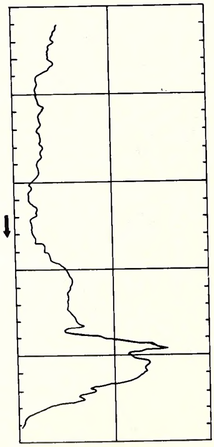
PA—8G



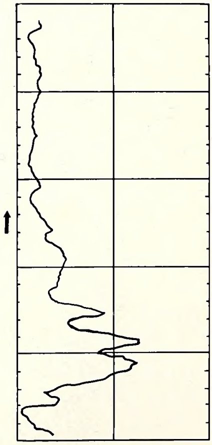
PA—9G



PA—10G

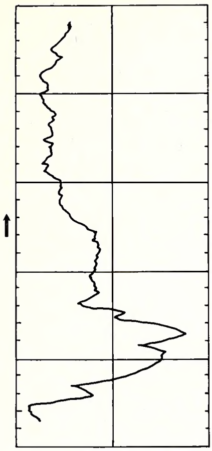


PA—11G

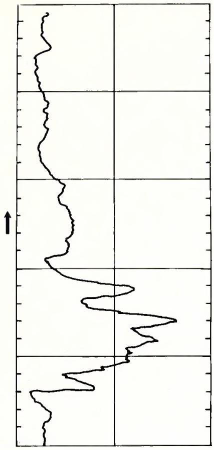


PA—12G

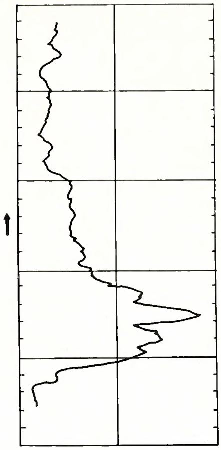
PLATE #3 (continued)



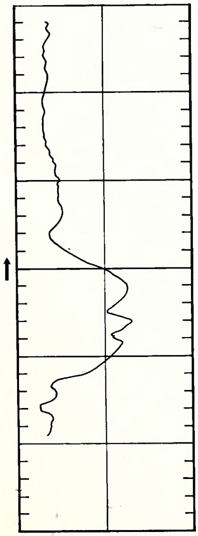
PA-13G



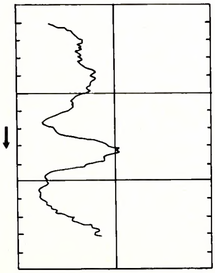
PA-14G



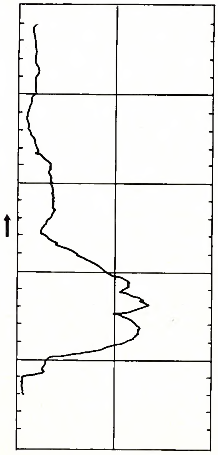
PA-15G



PA-16G

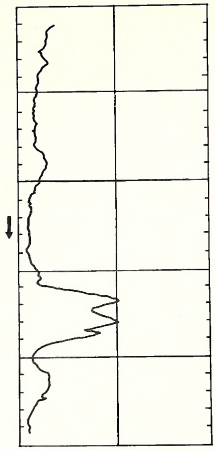


PA-17G

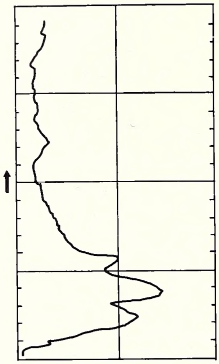


PA-18G

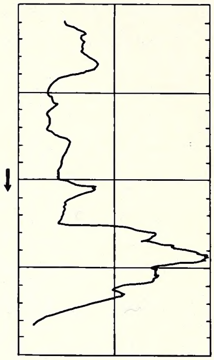
PLATE #3 (continued)



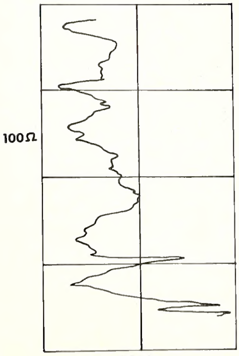
PA–19G



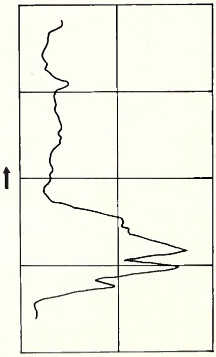
PA–20G



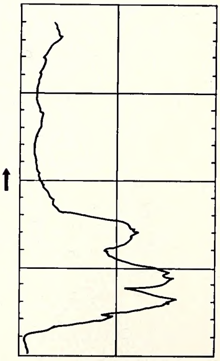
PA–21G



PA–22GRL

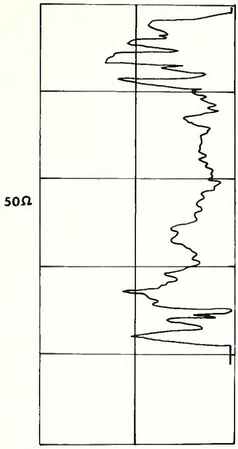


PA–22GRL

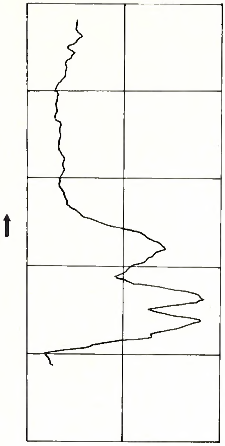


PA–23G

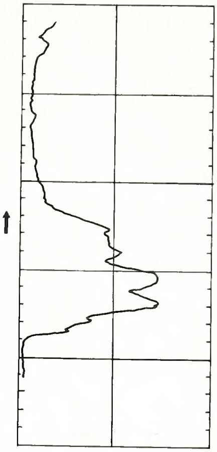
PLATE #3 (continued)



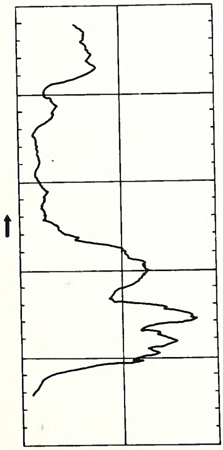
PA –24GRL



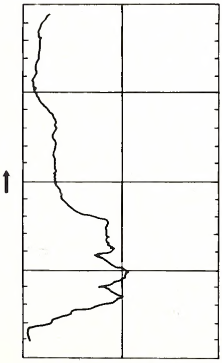
PA–24GRL



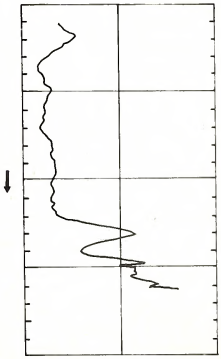
PA –25G



PA–26G

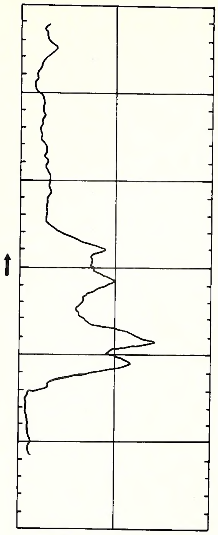


PA–27G

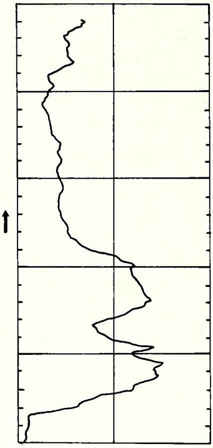


PA– 28G

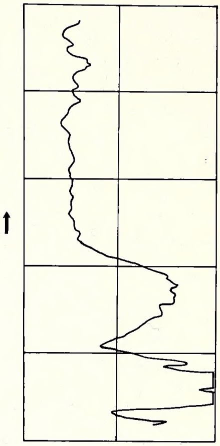
PLATE #3 (continued)



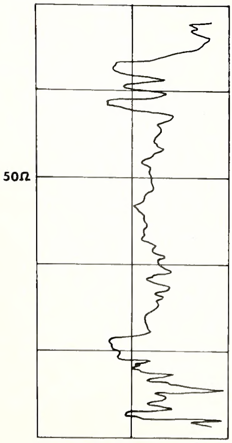
PA−29G



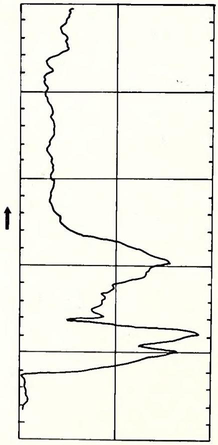
PA−30G



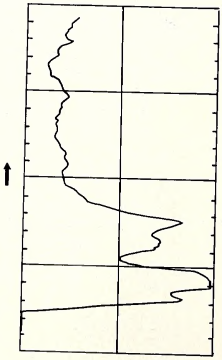
PA−31GRL



PA−31GRL

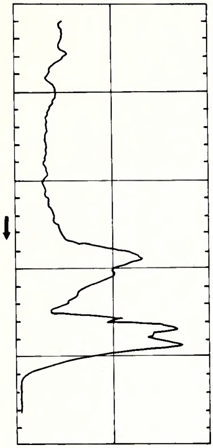


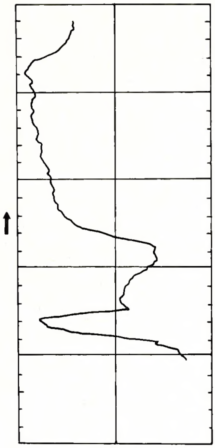
PA−32G



PA−33G

PLATE #3 (continued)


PA-34G


PA-35G

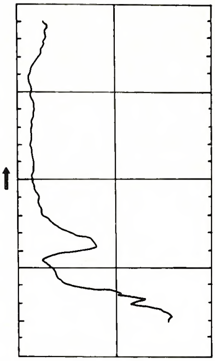
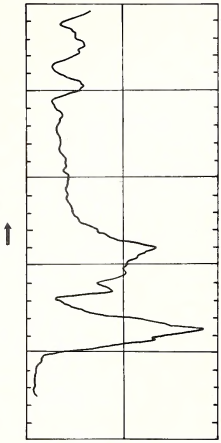
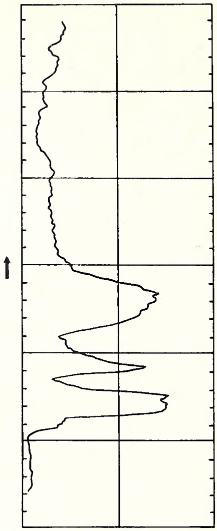

PA-36G

PLATE #4

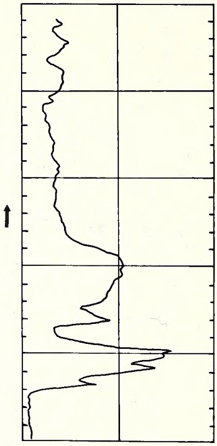
Geophysical logs in Ransomville Quadrangle



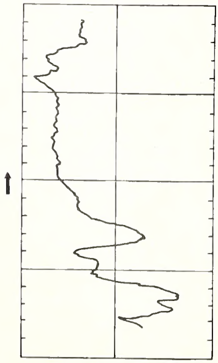
RA—1G



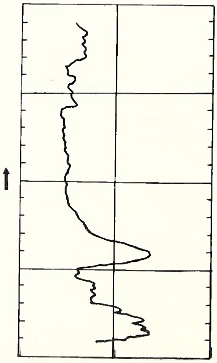
RA—2G



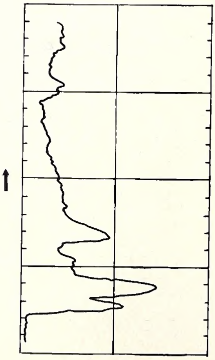
RA—3G



RA— 4G

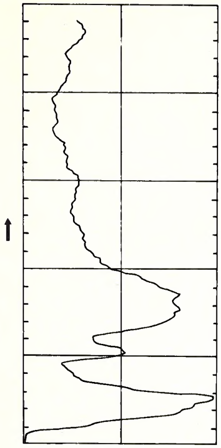


RA—5G

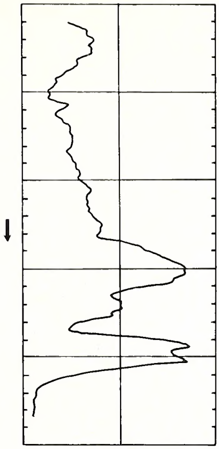


RA—6G

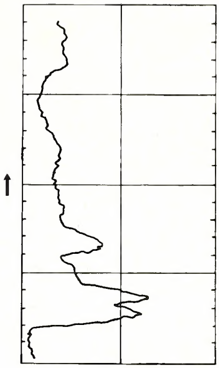
PLATE #4 (continued)



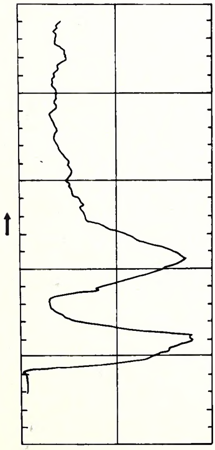
RA–7G



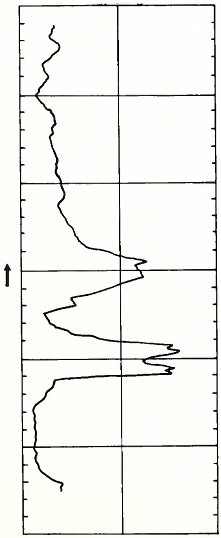
RA–8G



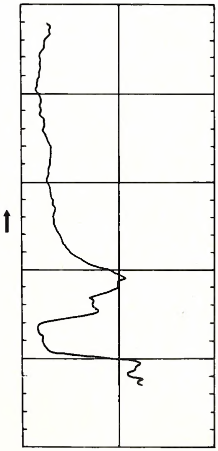
RA–9G



RA–10G

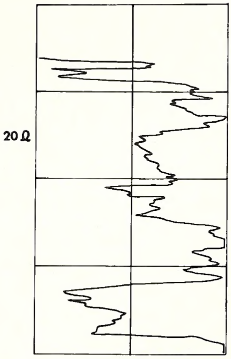


RA–11G

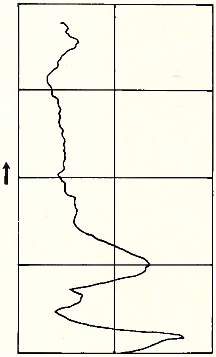


RA–12G

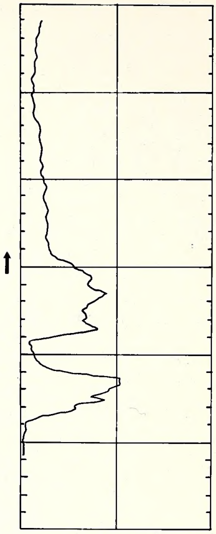
PLATE #4 (continued)



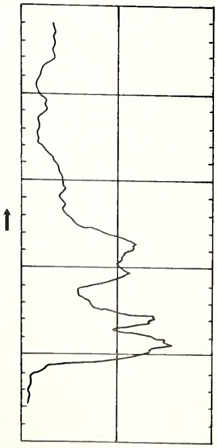
RA–13GRL



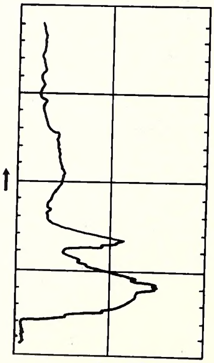
RA–13GRL



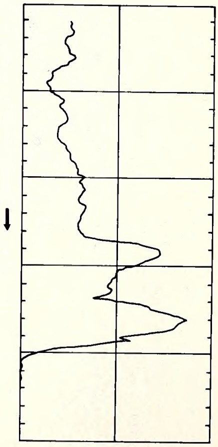
RA–14G



RA–15G

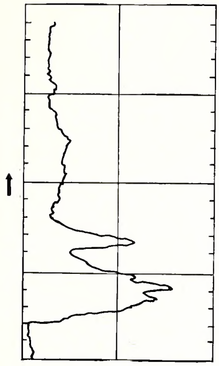


RA– 16G

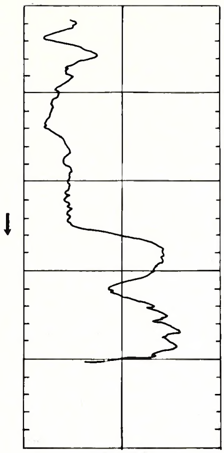


RA–17G

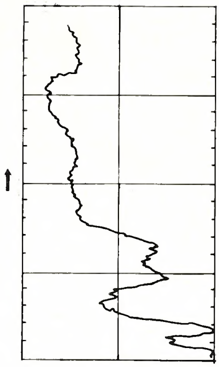
PLATE #4 (continued)



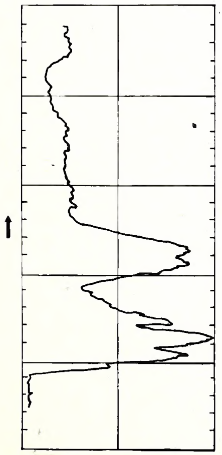
RA–18G



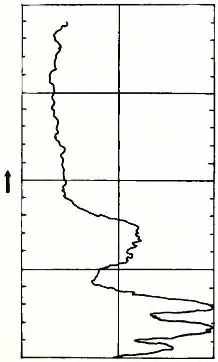
RA–19G



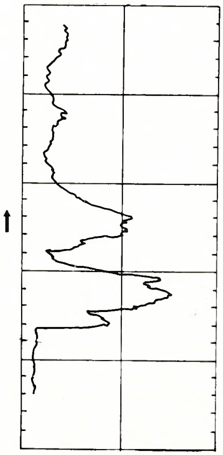
RA–20G



RA–21G

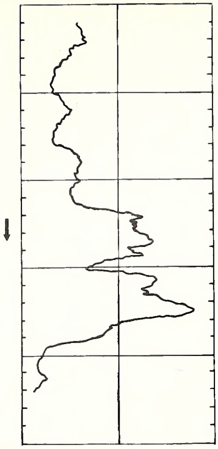


RA–22G

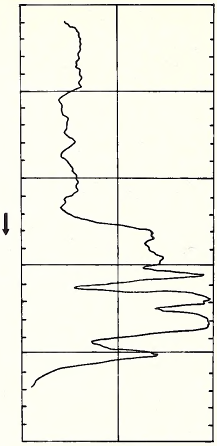


RA–23G

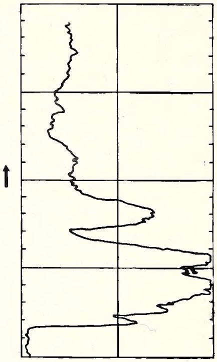
PLATE #4 (continued)



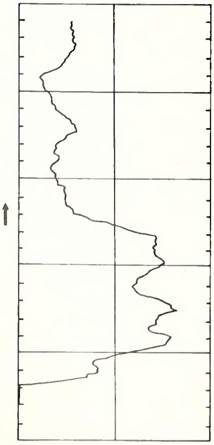
RA–24G



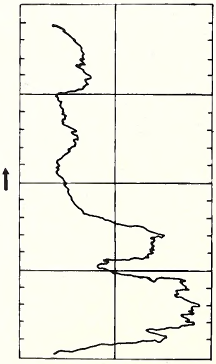
RA–25G



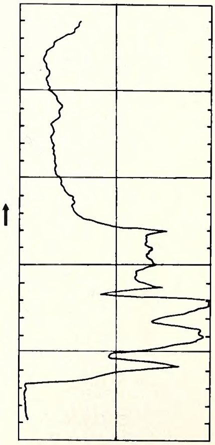
RA–26G



RA–27G

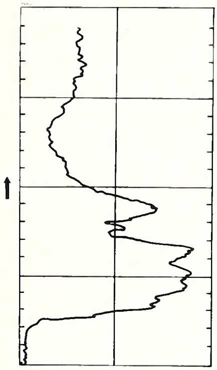


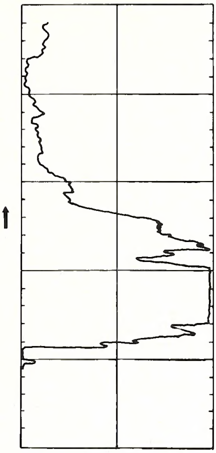
RA–28G

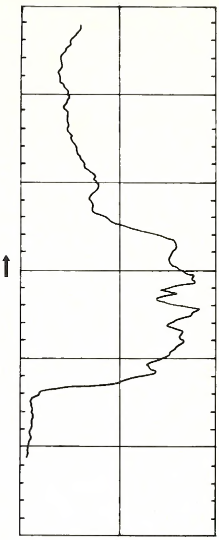


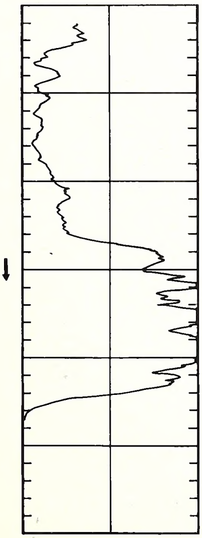
RA–29G

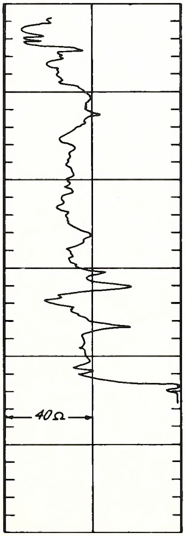
PLATE #4 (continued)


RA–30G

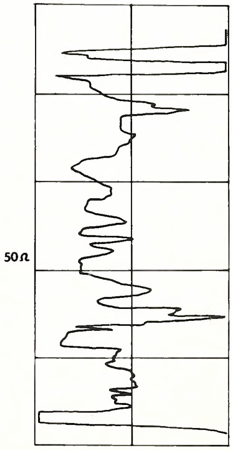

RA–31G


RA–32G


RA–33GR

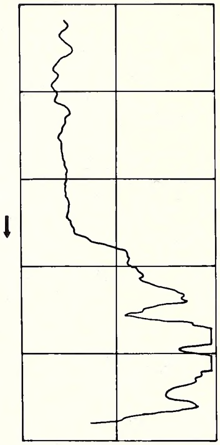


RA–33GR



RA–34GRL

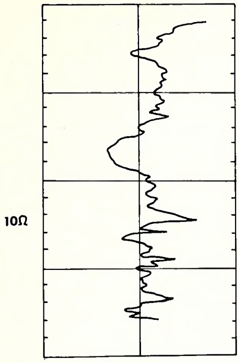
PLATE #4 (continued)



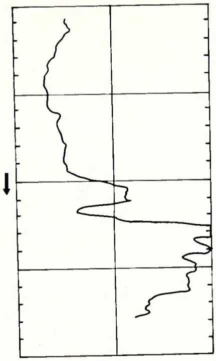
RA–34GRL

PLATE #5

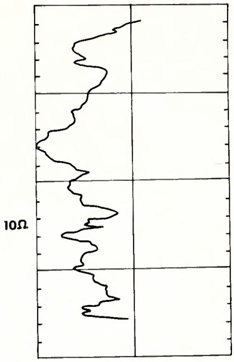
Geophysical logs in South Creek Quadrangle



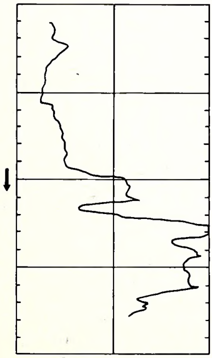
SC – 1GR



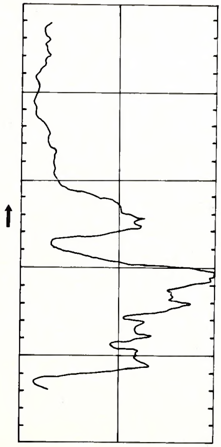
SC – 1GR



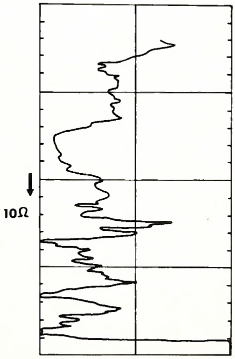
SC–2GR



SC–2GR

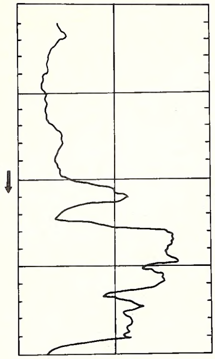


SC–3G

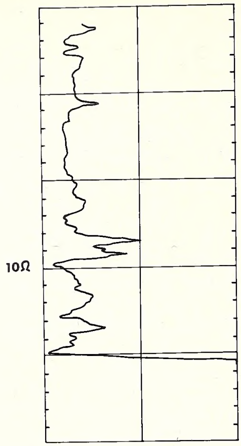


SC– 4GR

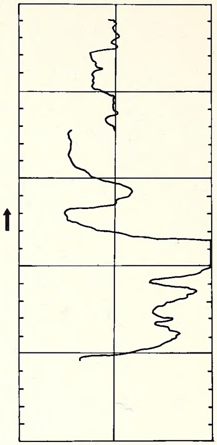
PLATE #5 (continued)



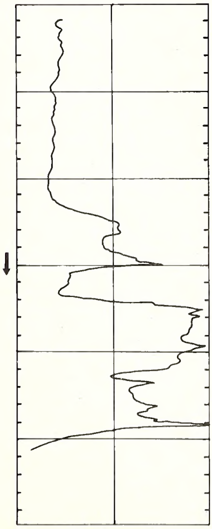
SC–4GR



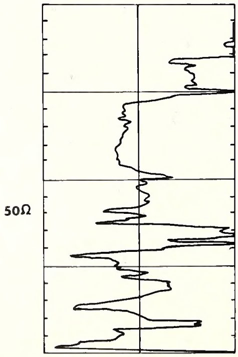
SC–5GR



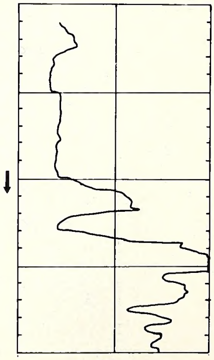
SC–5GR



SC–6GR

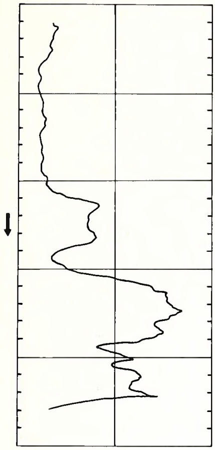


SC–7GR

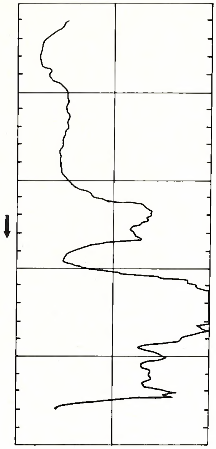


SC–7GR

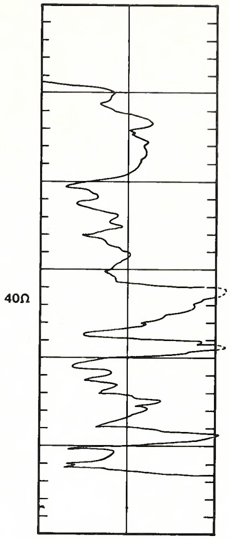
PLATE #5 (continued)



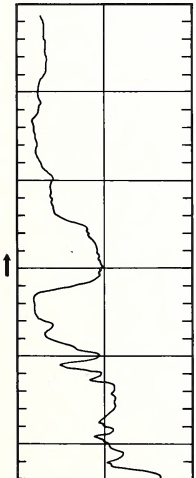
SC-8G



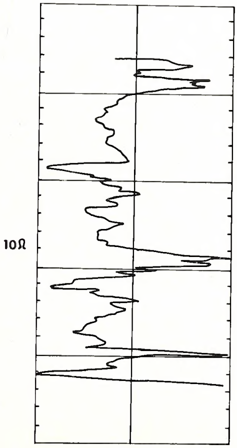
SC-9G



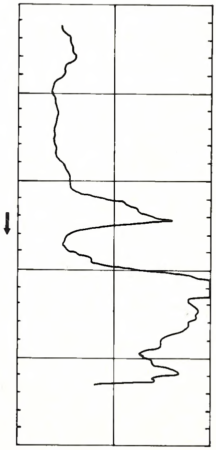
SC-10GRL



SC-10GRL

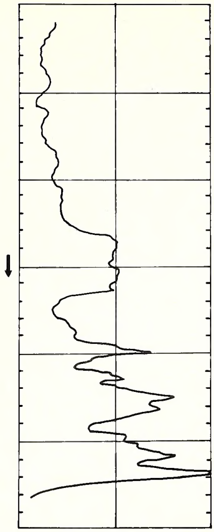


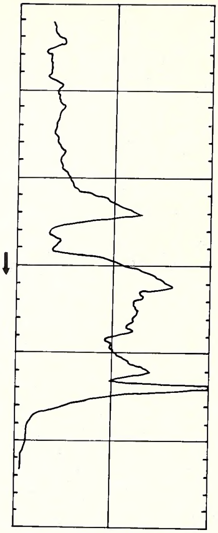
SC-11GR

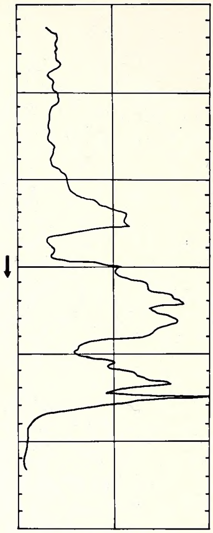


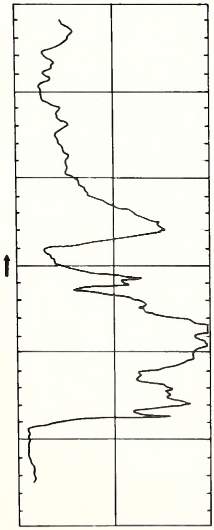
SC-11GR

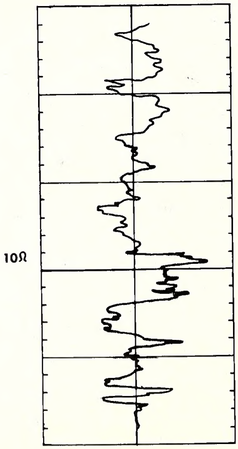
PLATE #5 (continued)


SC – 12G


SC – 13G


SC – 14G


SC – 15G



SC – 16GR

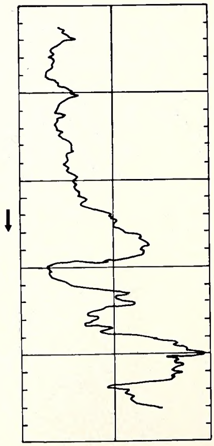
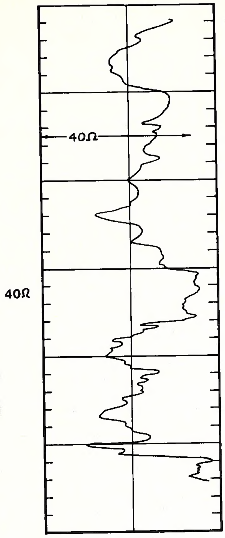
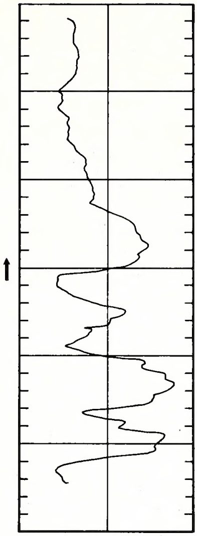

SC – 16GR

PLATE #5 (continued)



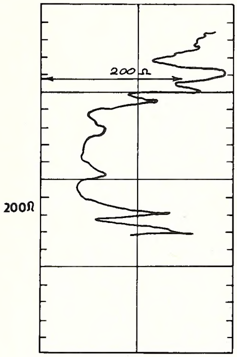
SC−17GRL



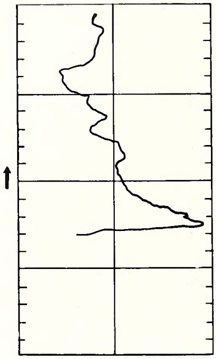
SC−17GRL

PLATE #6

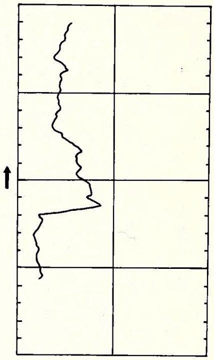
Geophysical logs in Pinetown Quadrangle



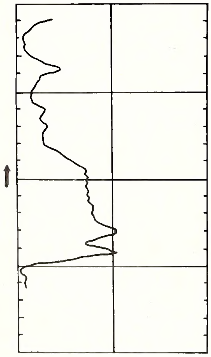
PI–1GRL



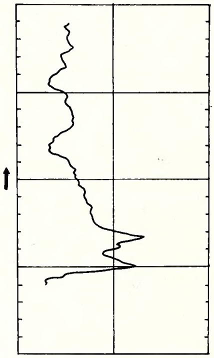
PI–1GRL



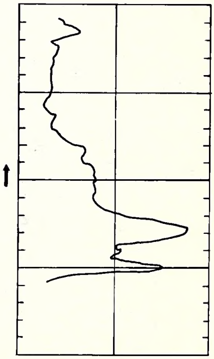
PI–2G



PI–3G

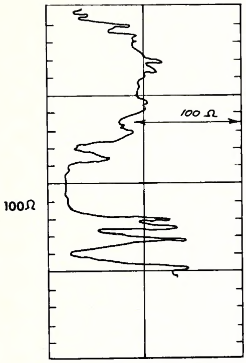


PI–4G

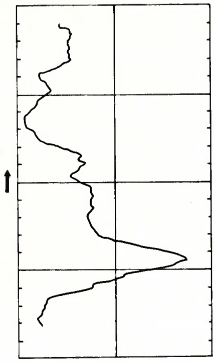


PI–5GRL

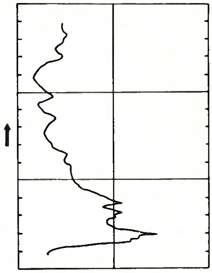
PLATE #6 (continued)



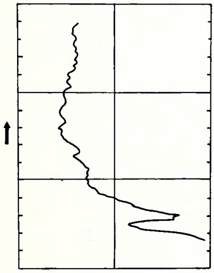
PI-5GRL



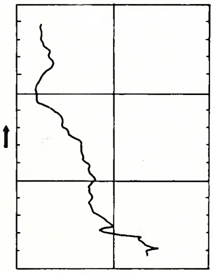
PI-6G



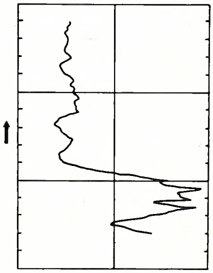
PI-7G



PI-8G

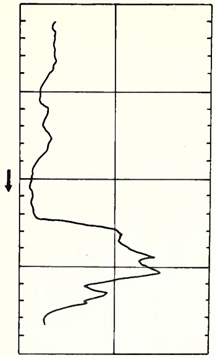


PI-9G

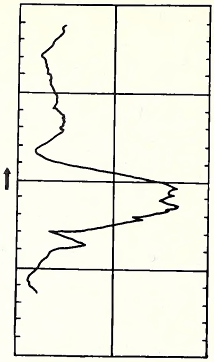


PI-10G

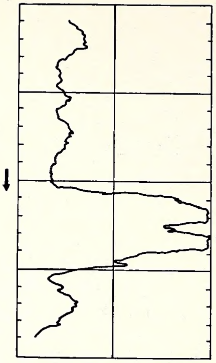
PLATE #6 (continued)



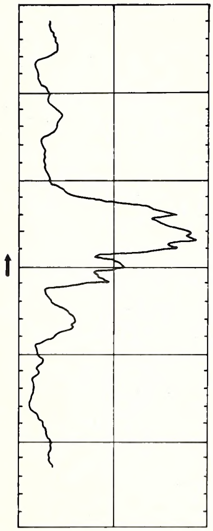
PI–11G



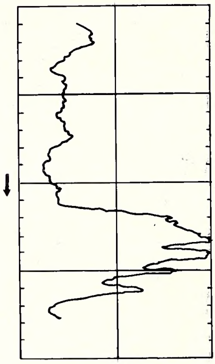
PI–12G



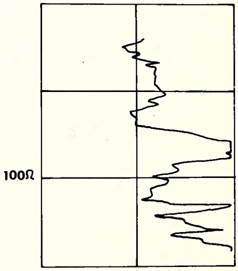
PI–13G



PI–14G

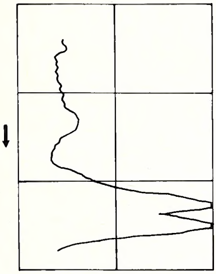


PI–15G

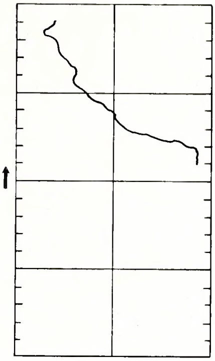


PI–16GRL

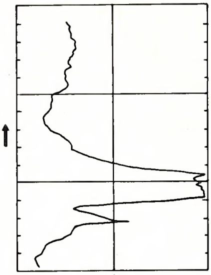
PLATE #6 (continued)



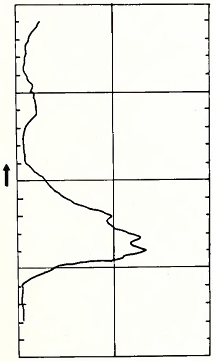
PI–16GRL



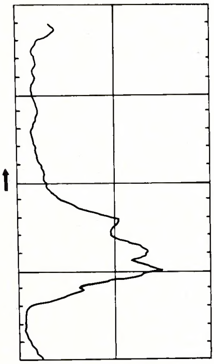
PI–17G



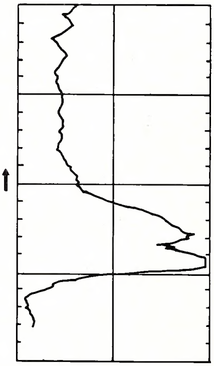
PI–18G



PI–19G

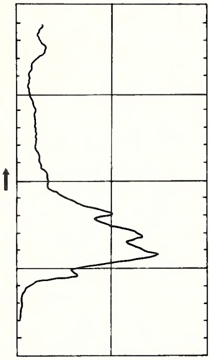


PI–20G

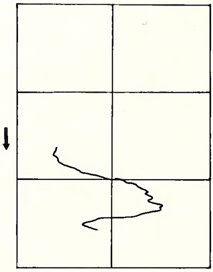


PI–21G

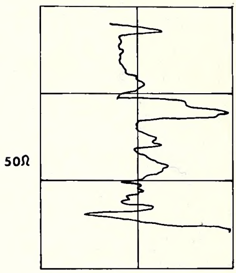
PLATE #6 (continued)



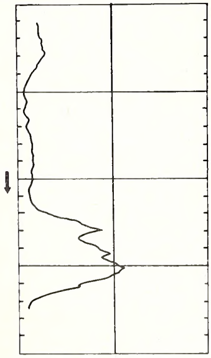
P1–22G



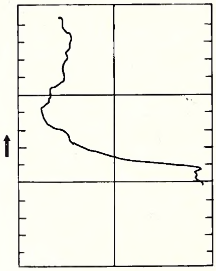
P1–23GRL



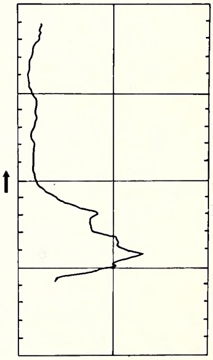
P1–23GRL



P1–24G

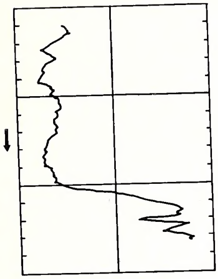


P1–25G

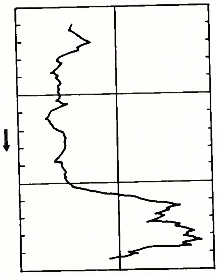


P1–26G

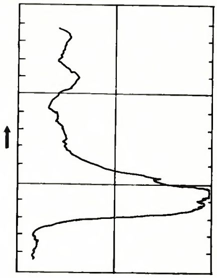
PLATE #6 (continued)



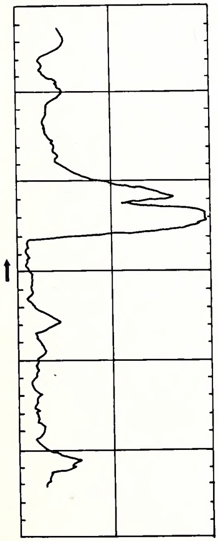
PI-27G



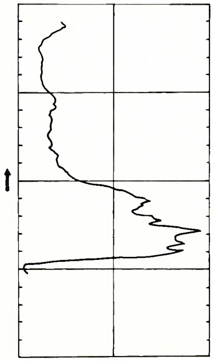
PI-28G



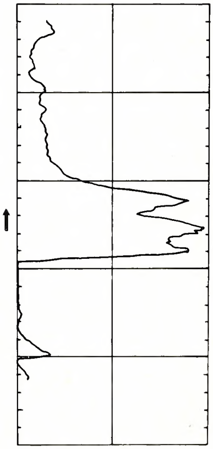
PI-29G



PI-30G

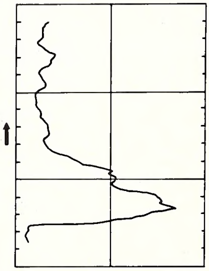


PI-31G

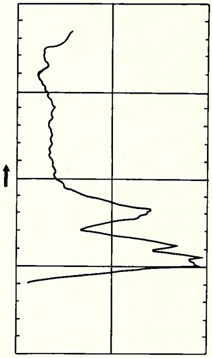


PI-32G

PLATE #6 (continued)



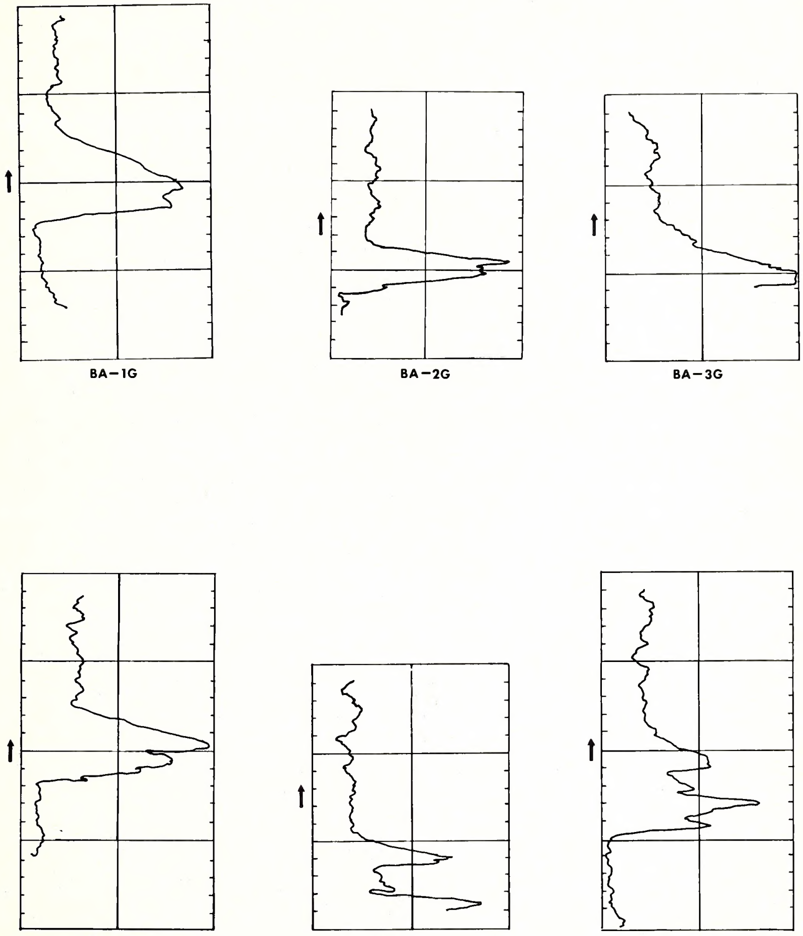
PI-33G



PI-34G

PLATE #7

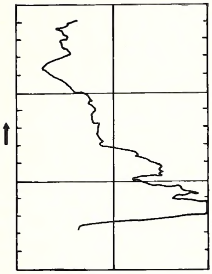
Geophysical logs in Bath Quadrangle

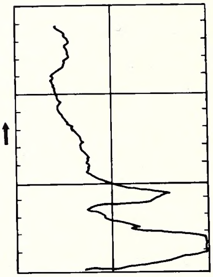


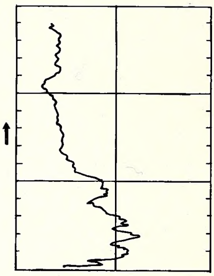
BA–1G BA–2G BA–3G

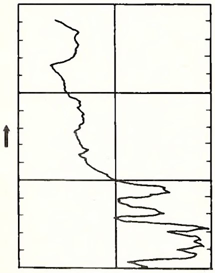
BA–4G BA–5G BA–6G

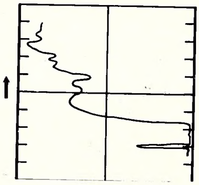
PLATE #7 (continued)


BA−7G


BA−8G


BA−9G


BA−10G


BA−11G

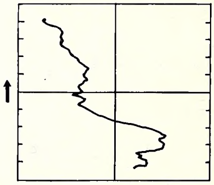
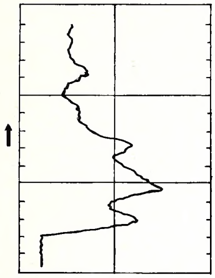
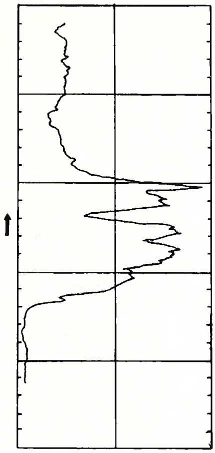
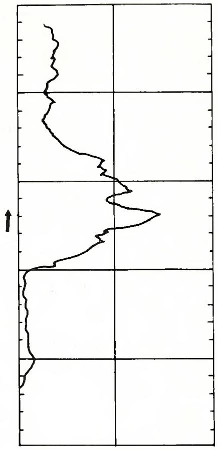
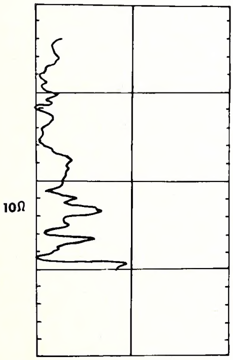

BA−12G

PLATE #7 (continued)

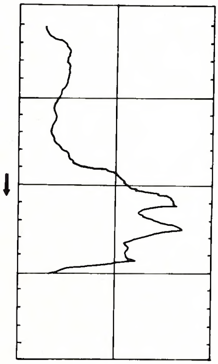

BA–13G


BA–14G


BA–15G



BA–16GR


BA–16GR

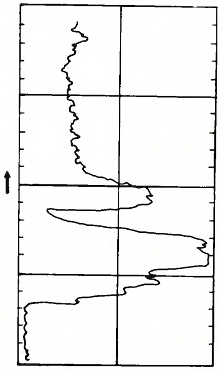
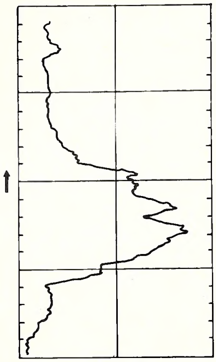
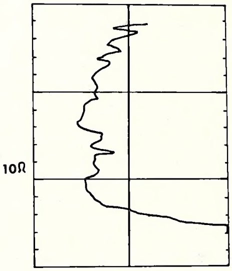
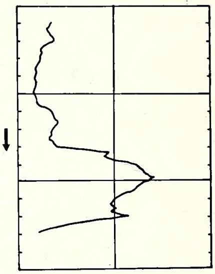

BA–17G

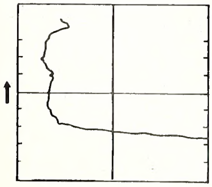
PLATE #7 (continued)

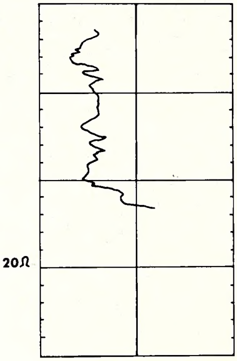

BA–18G



BA–19GR


BA–19GR


BA –20G



BA–21GR

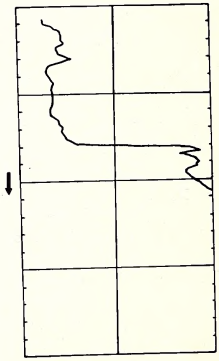

BA–21GR

PLATE #7 (continued)

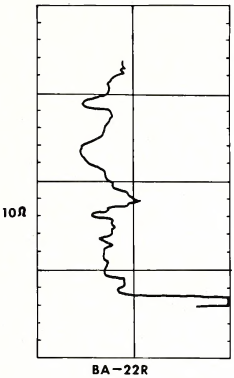
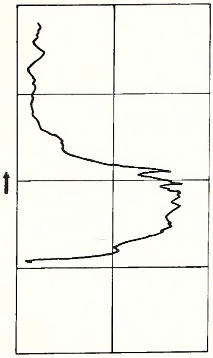
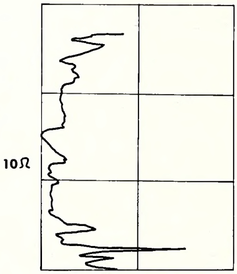


PLATE #8

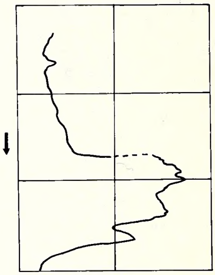
Geophysical logs in Aurora Quadrangle



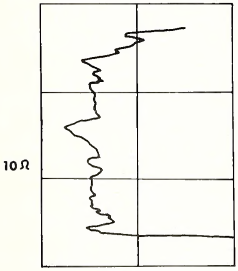
AU – 1G



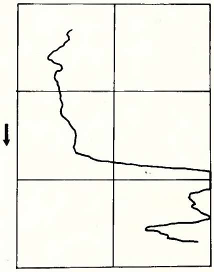
AU – 2GR



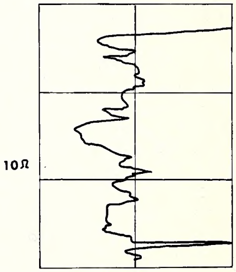
AU – 2GR



AU – 3GR

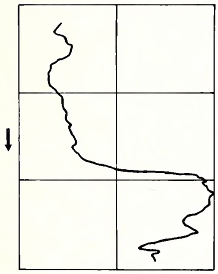


AU – 3GR

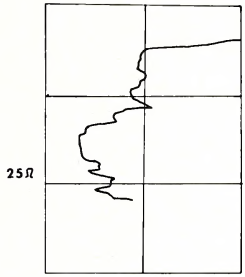


AU – 4GR

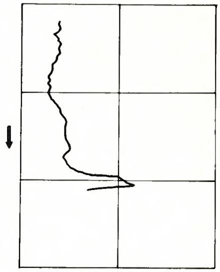
PLATE #8 (continued)



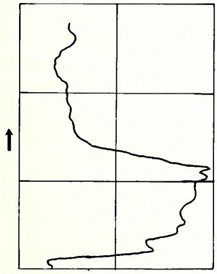
AU– 4GR



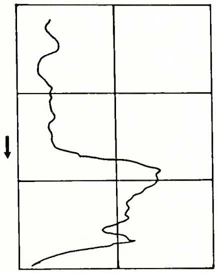
AU–5GR



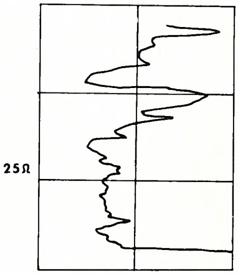
AU–5GR



AU –6G

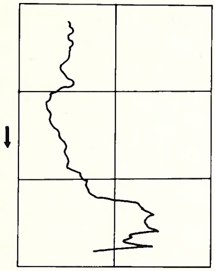


AU–7G

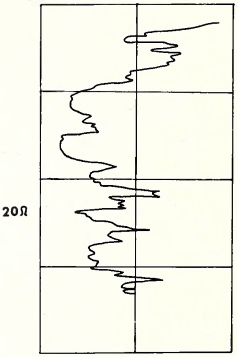


AU– 8GR

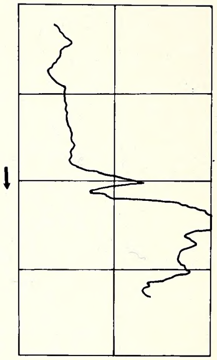
PLATE #8 (continued)



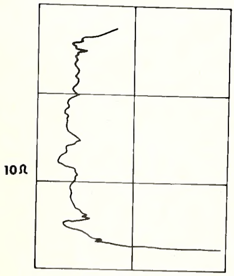
AU−8GR



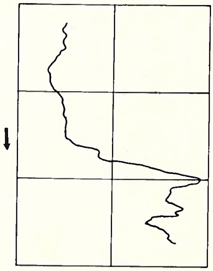
AU−9GR



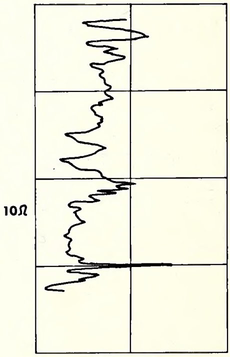
AU−9GR



AU − 10GR

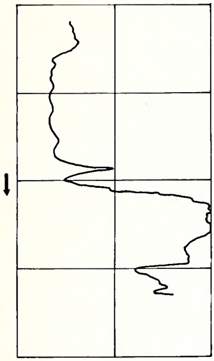


AU −10GR

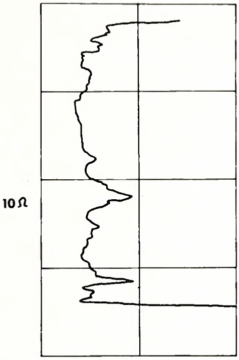


AU −11GR

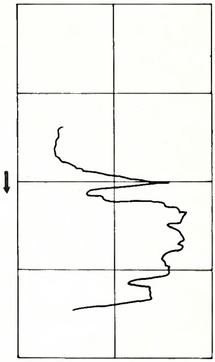
PLATE #8 (continued)



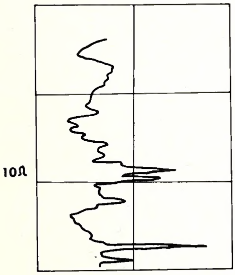
AU–11GR



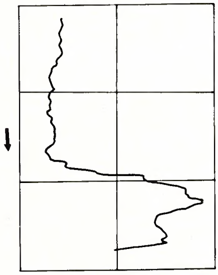
AU–12GR



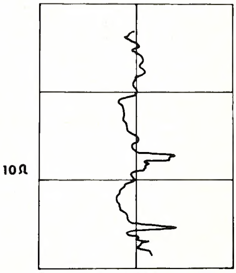
AU–12GR



AU–13GR

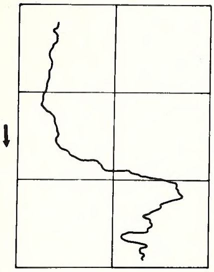


AU–13GR

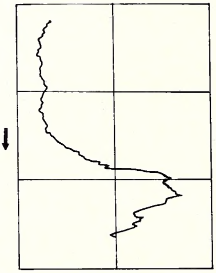


AU–14GR

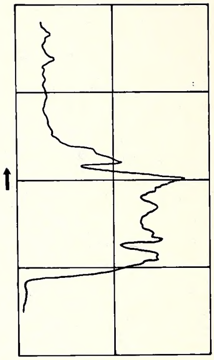
PLATE #8 (continued)



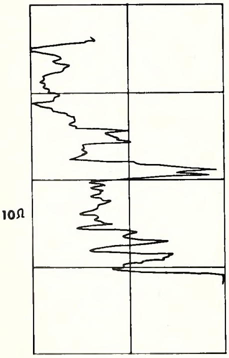
AU −14GR



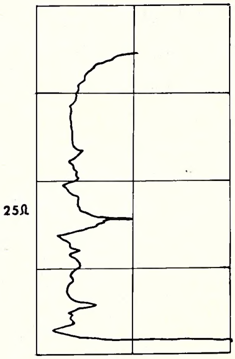
AU−15G



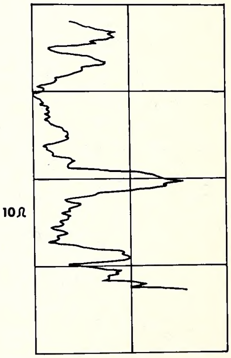
AU−16G



AU−17R

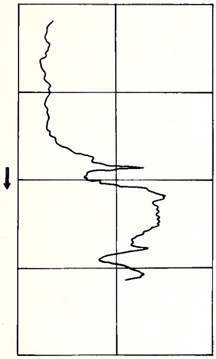


AU−18R

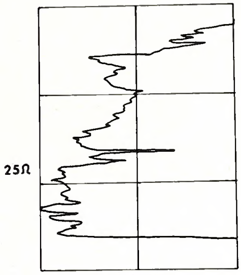


AU−19GR

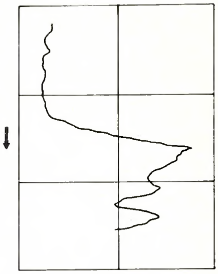
PLATE #8 (continued)



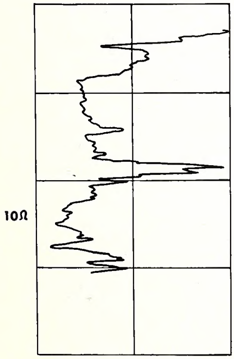
AU–19GR



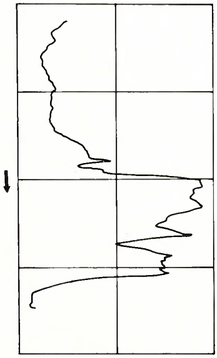
AU–20GR



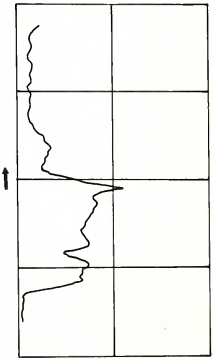
AU–20GR



AU– 21GR

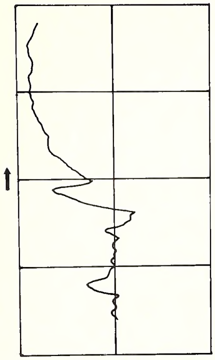


AU–21GR

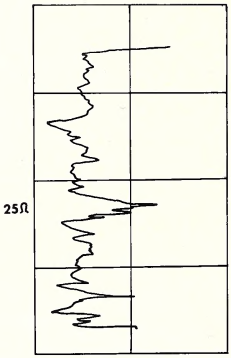


AU–22G

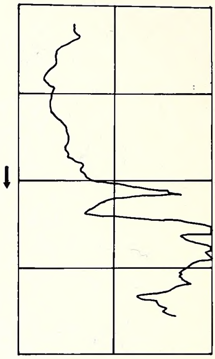
PLATE #8 (continued)



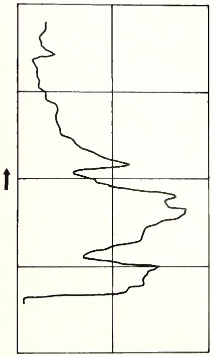
AU–23G



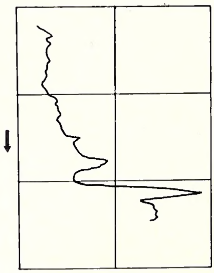
AU–24GR



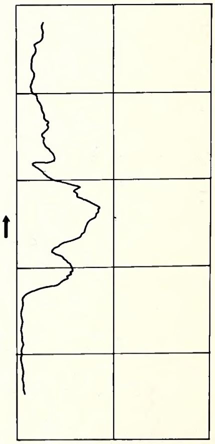
AU–24GR



AU –25G

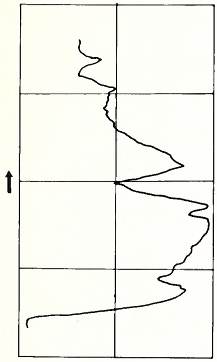


AU–26G

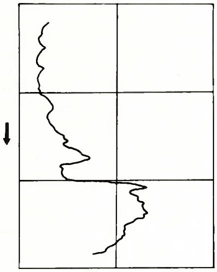


AU–27G

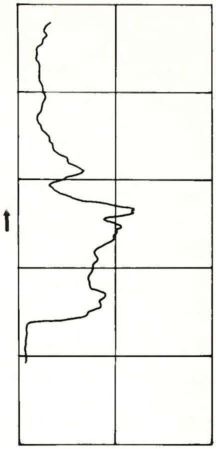
PLATE #8 (continued)



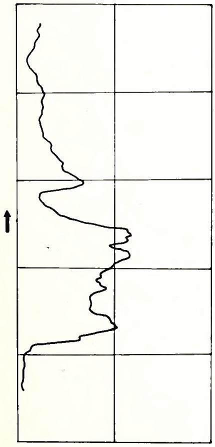
AU-28G



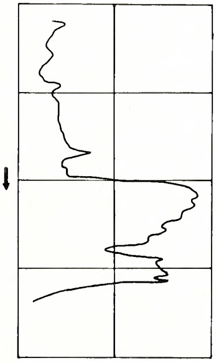
AU-29G



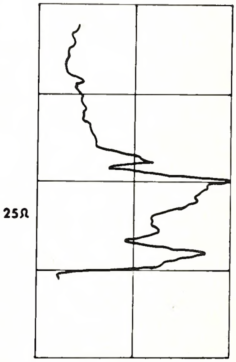
AU-30G



AU-31G

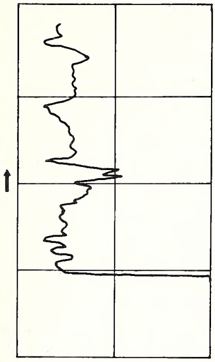


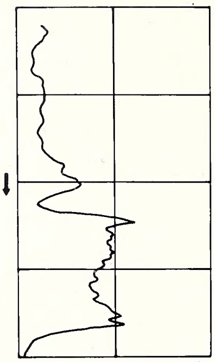
AU-32G

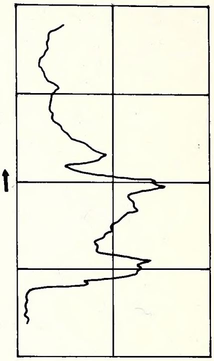


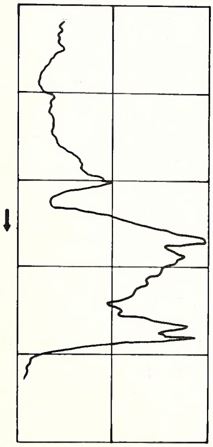
AU-33GR

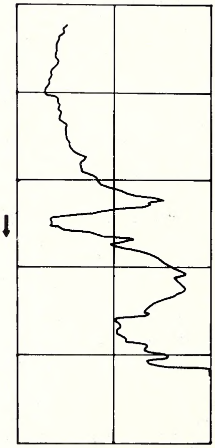
PLATE #8 (continued)

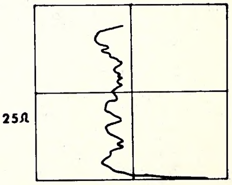

AU−33GR


AU−34G


AU−35G

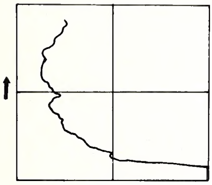

AU−36G


AU−37G

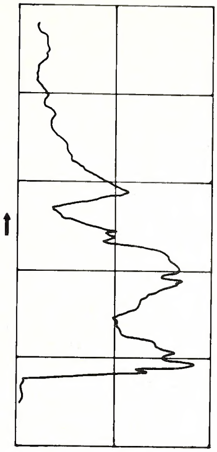


AU−38GR

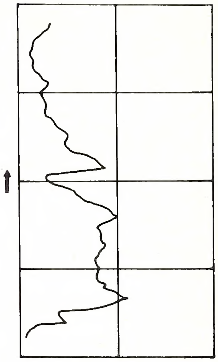
PLATE #8 (continued)



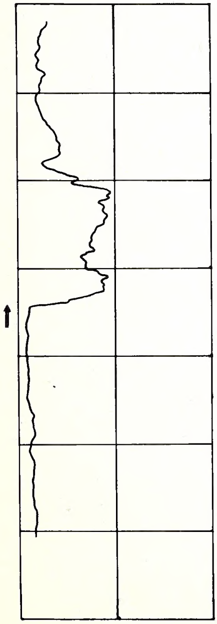
AU-38GR



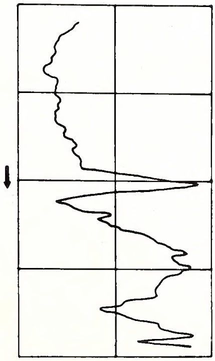
AU-39G



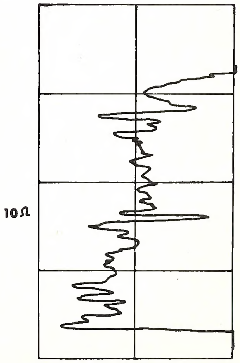
AU-40G



AU-41G

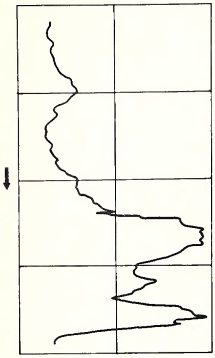


AU-42G

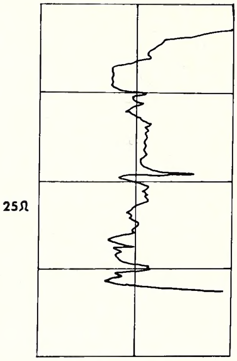


AU-43GR

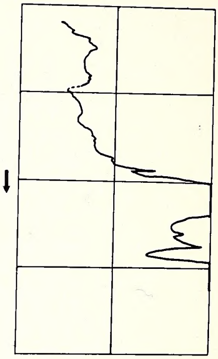
PLATE #8 (continued)



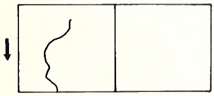
AU −43GR



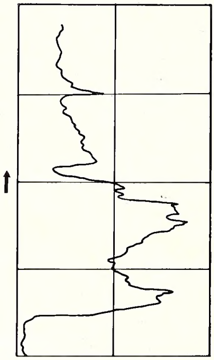
AU −44GR



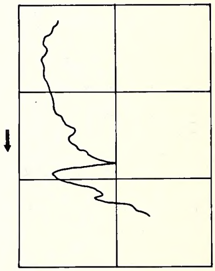
AU−44GR



AU−45G

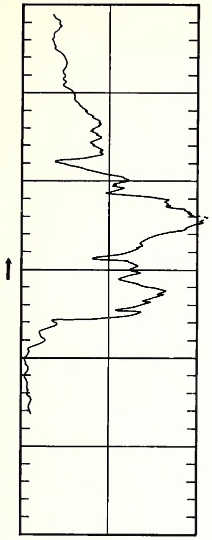


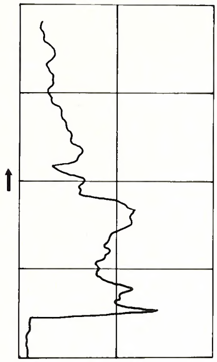
AU−46G

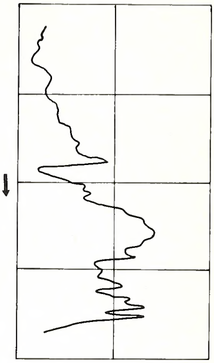


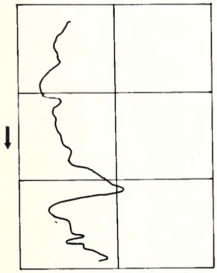
AU −47G

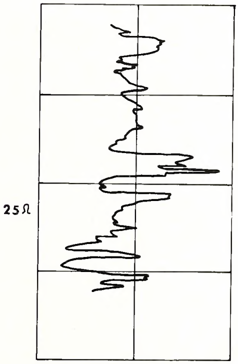
PLATE #8 (continued)


AU−48G


AU−49G


AU−50G


AU−51G



AU−52GR

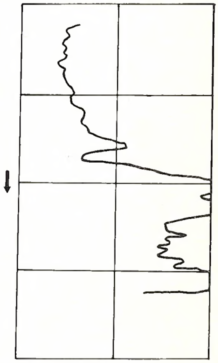
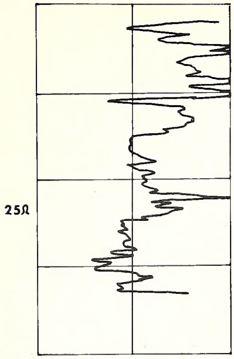
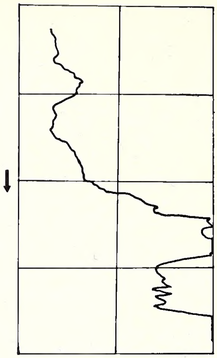

AU−52GR

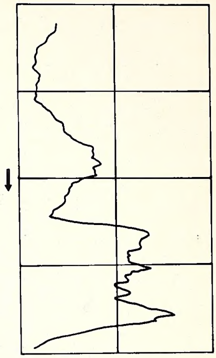
PLATE #8 (continued)



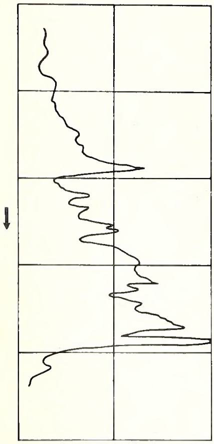
AU-53GR



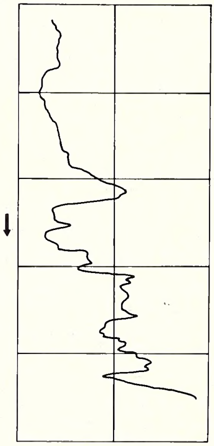
AU-54G



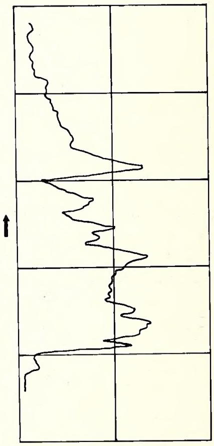
AU-55G



AU-56G

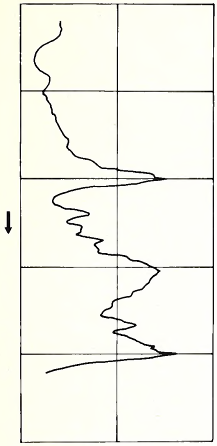


AU-57G

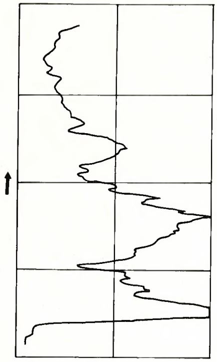


AU-58G

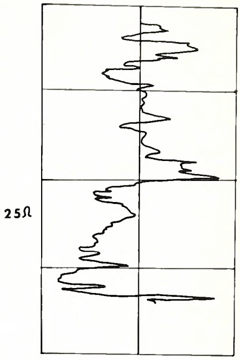
PLATE #8 (continued)



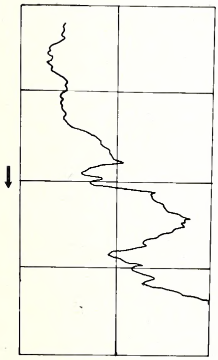
AU-59G



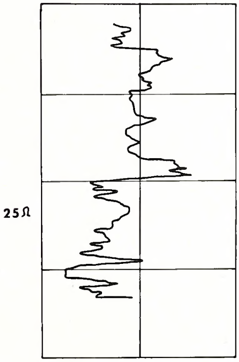
AU-60G



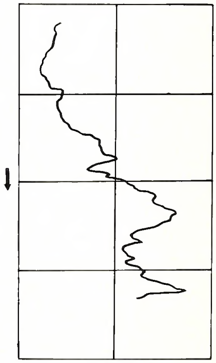
AU-61GR



AU-61GR

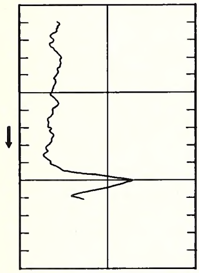


AU-62GR

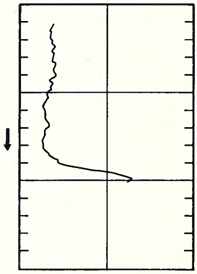


AU-62GR

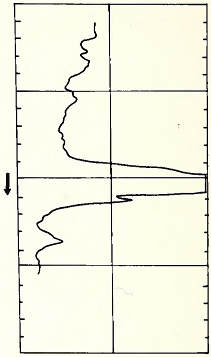
PLATE #9
Geophysical logs in Bunyan Quadrangle



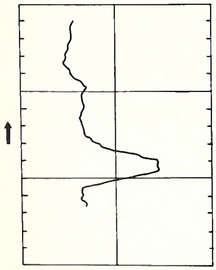
BU−1G



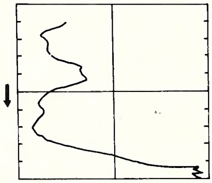
BU−2G



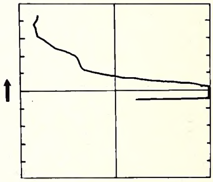
BU−3G



BU−4G

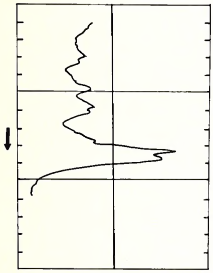


BU−5G

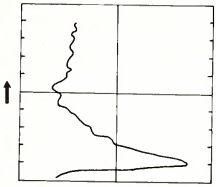


BU−6G

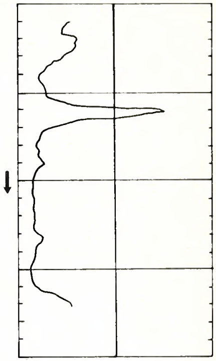
PLATE #9 (complete)



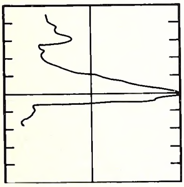
BU−7G



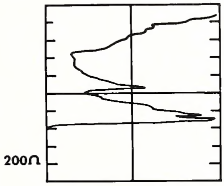
BU−8G



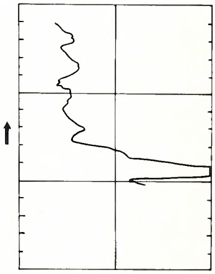
BU−9G



BU −10GRL

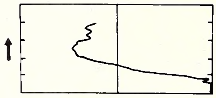


BU−10GRL



BU−11G

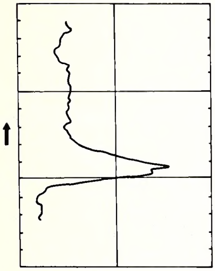
PLATE #9 (complete)

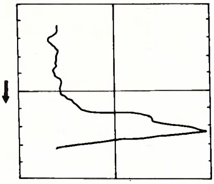


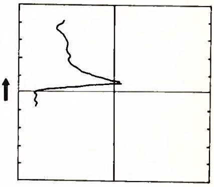
BU–12G

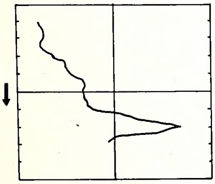
PLATE #10

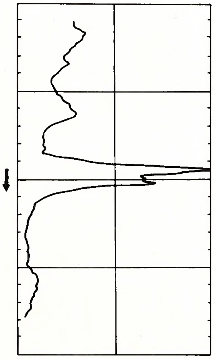
Geophysical logs in Blounts Bay Quadrangle


BB—1G


BB—2G


BB—3G


BB—4G


BB—5G

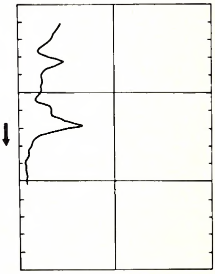
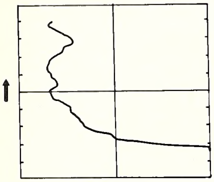
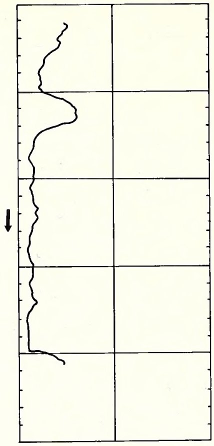

BB—6G

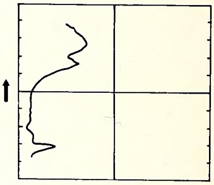
PLATE #10 (continued)



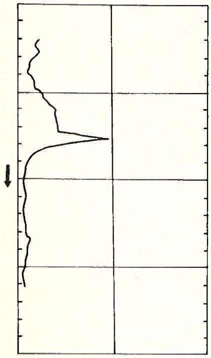
BB–7G



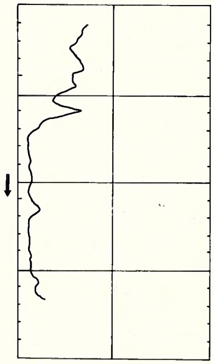
BB–8G



BB–9G



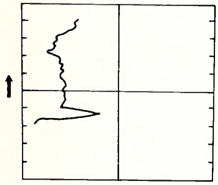
BB–10G



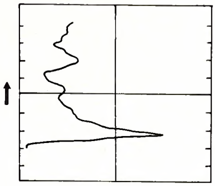
BB–11G

PLATE #11

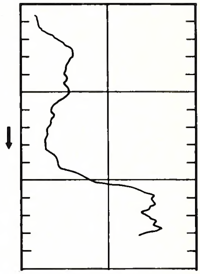
Geophysical logs in Edward Quadrangle



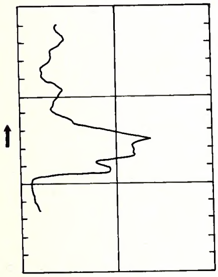
ED—1G



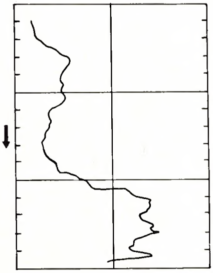
ED—2G



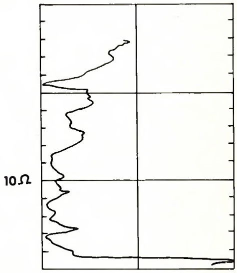
ED—3G



ED—4G

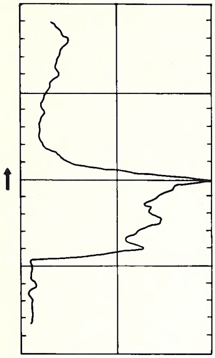


ED—5GR

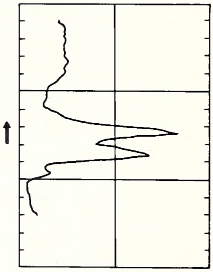


ED—5GR

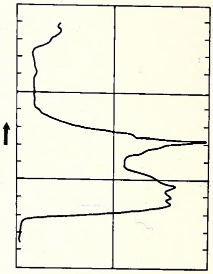
PLATE #11 (continued)



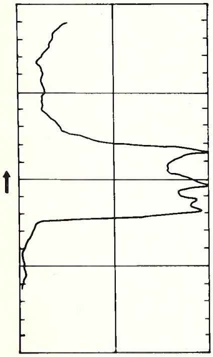
ED–6G



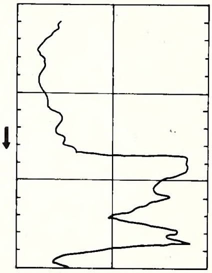
ED–7G



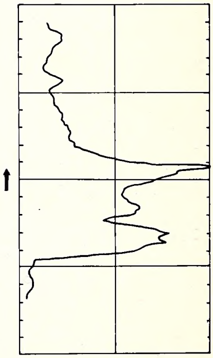
ED–8G



ED – 9G

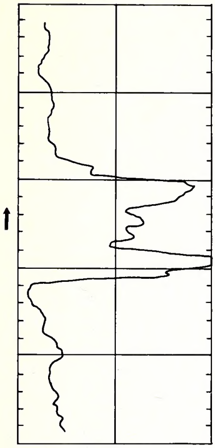


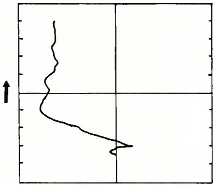
ED – 10G

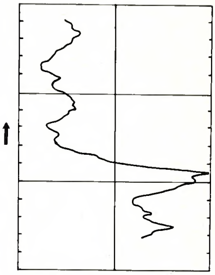


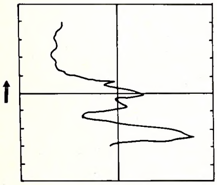
ED–11G

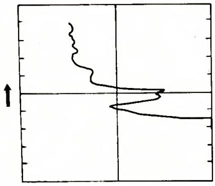
PLATE #11 (continued)


ED−12G


ED−13G


ED−14G


ED−15G


ED−16G